OECD Environmental Outlook for the Chemicals Industry

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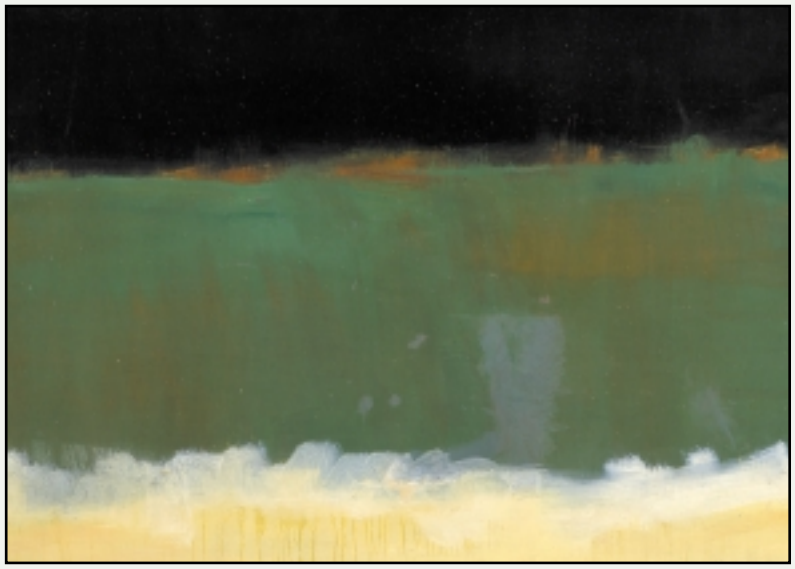

OECD

Environmental Outlook for the Chemicals Industry

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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The work of the OECD related to industrial chemicals, pesticides and biotechnology is carried out by the Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology, with Secretariat support from the Environment, Health and Safety Division of the Environment Directorate. The Environment, Health and Safety Division publishes documents in several different series, including: **Testing and Assessment**; **Good Laboratory Practice and Compliance Monitoring**; **Pesticides**; **Risk Management**; **Harmonization of Regulatory Oversight in Biotechnology**; **PRTRs (Pollutant Release and Transfer Registers)**; and **Chemical Accidents**. More information about the Environmental Health and Safety Programme and EHS publications is available on the OECD's web site (see below).

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or contact:

OECD Environment Directorate
Environment, Health and Safety Division
2 rue André-Pascal
75775 Paris Cedex 16
France

Facsimile: (33-1) 45 24 16 75
E-mail: ehscont@oecd.org

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FOREWORD

The OECD Chemicals Programme has worked since 1978 to assist OECD governments in the field of chemicals and pesticides safety. While developing policies and instruments for protecting human health and the environment from risks presented by chemicals, the Chemicals Programme also promotes the optimal use of government and industry resources in doing so. By working together to harmonize policies across OECD countries, duplicative efforts and animal testing are avoided, time and money are saved and non-tariff barriers to trade are minimised. The products of this OECD Programme contribute in a major way to the implementation of sustainable development and the recommendations in Chapter 19 of "Agenda 21" which was developed at the 1992 United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil.

When Environment Ministers in 1998 asked the OECD for a forward-looking environmental strategy, the OECD Environment Policy Committee considered that such a strategy could only be credible if underpinned by an environmental outlook which analyses trends and provides projections for the future. It was only logical that the Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology in turn considered that the chapter on the chemicals industry for this overall environmental outlook should also be based on a substantial analysis. The following report gives the trends and future projections to 2020 concerning economic and environmental developments relevant to the chemicals industry. It is based on the long experience of the Chemicals Programme, and also uses information from other parts of the Environment Directorate and other OECD Directorates and affiliated Agencies.

Richard Sigman was the main author of the report; Barbara Ladeuille handled the technical production. Many other staff of the Environment, Health and Safety Division, in particular Nicky Grandy, have contributed to this publication. In addition, many experts in OECD countries, from government and the chemicals industry, trade unions and environmental groups, have provided useful input to this OECD Environmental Outlook for the Chemicals Industry. It is published under the responsibility of the Secretary-General of the OECD.

1. SUMMARY OF THE ENVIRONMENTAL OUTLOOK FOR THE CHEMICALS INDUSTRY

The chemicals industry makes products with many beneficial uses, but they can also have negative impacts on human health and the environment.

Chemicals are used to make virtually every man-made product and play an important role in the everyday life of people around the world. Such products provide protection for crops and increase yields, prevent and cure disease, provide insulation to reduce energy use and provide countless other benefits that make life better for people. But, while the chemicals industry has made good progress reducing its overall environmental footprint, chemicals can also create a negative impact on human health and the environment when their production and use are not managed responsibly. Although the impacts are complex and often unknown or sometimes open to debate, some negative effects are well documented, such as chemicals found in the environment that are persistent, bioaccumulative and/or toxic (*e.g.* PCBs, dioxins). Most recently, concern has been expressed about chemicals which interfere with the normal function of hormonal systems of humans and animals (*i.e.* endocrine disrupters), and substances which impact on children's health.

The industry has made good progress in reducing emissions from chemical plants and the energy they use, but the current lack of safety data on chemicals and the changes that will occur in the industry over the coming years pose major challenges to policy makers.

The chemicals industry is one of the most regulated of all industries. In addition to the regulation of its products, it is also subject to a number of requirements aimed at minimising releases of chemical substances during manufacturing and processing. The chemicals industry in OECD countries has made good progress in reducing emissions and energy use and in designing safer plants.

Much effort has been spent over the years on testing and assessing chemicals, but there are still many questions and gaps in our knowledge about their characteristics, effects and use patterns, and resultant impacts on man and the environment. The lack of knowledge about most chemical substances on the market and the products in which they are used, and consequently the uncertainty about whether workers, the public and the environment are being adequately protected, is a major challenge to policy makers today. As the chemicals industry is becoming more global in nature, there will be additional challenges (and opportunities) for governments and industry to better manage chemical safety.

Governments and industry will need to continue to build on past achievements, but also develop new approaches for managing chemicals.

It is expected that this will lead to:

- greater focus on the safety of chemicals and products from their design to manufacture and final disposal;
- increasing involvement of all stakeholders by shifting more responsibility to industry for the generation of data on all chemicals on the market, and a bigger role for industry in assessing this data, while at the same time making such data and assessments widely available and encouraging stakeholder oversight; and
- increasing outreach to non-OECD countries to help them build up their chemical safety infrastructure to cope with the rapid expansion of their chemicals industries.

The industry

The chemicals industry is very diverse, producing thousands of substances which are used by other industries and that are present in countless consumer products.

The chemicals industry is very diverse, comprising basic or commodity chemicals; speciality chemicals derived from basic chemicals (adhesives and sealants, catalysts, coatings, electronic chemicals, plastic additives, *etc.*); products derived from life sciences (pharmaceuticals, pesticides and products of modern biotechnology); and consumer care products (soap, detergents, bleaches, hair and skin care products, fragrances, *etc.*). The global chemicals industry today produces tens of thousands of substances (some in volumes of millions of metric tonnes, but most of them in quantities of less than 1000 tonnes per year). The substances can be mixed by the chemicals industry and sold and used in this form, or they can be mixed by downstream customers of the chemicals industry (*e.g.* retail stores which sell paint). It is important to note that most of the output from chemical companies is used by other chemical companies or other industries (*e.g.* metal, glass, electronics), and chemicals produced by the chemicals industry are present in countless products used by consumers (*e.g.* automobiles, toys, paper, clothing).

It is an important part of the world economy...

The global chemicals industry is an important part of the world economy with an estimated US$1500 billion in sales in 1998 - more than twice the size of the world market for telecommunications equipment and services - and it accounts for 7% of global income and 9% of international trade. The industry is a major employer with over 10 million people employed worldwide, and traditionally a “high tech” industry with a heavy reliance on research and development due to the constant need for innovation.

...with the bulk of production and trade occurring in OECD countries.

Almost every country has a chemicals industry, yet almost 80% of the world’s total output is currently being produced by only 16 countries: the US, Japan, Germany, China, France, the UK, Italy, Korea, Brazil, Belgium/Luxembourg, Spain, the Netherlands, Taiwan, Switzerland and Russia. Consumption of chemicals is far greater in OECD countries than in non-OECD countries. Similarly, trade in chemicals is currently dominated by OECD regions which have nearly equilibrated

trade balances with one another and register trade surpluses with virtually all the other regions of the world.

The industry will continue to expand over the next 20 years, with faster growth rates in non-OECD countries.

All economic indicators point to continued expansion of the industry over the next 20 years. Since 1970, global sales have grown almost nine-fold and annual sales growth is expected to continue at around 3% per year. Trade will also increase considerably over the next 20 years.

Chemical companies in OECD countries will shift production to life science and speciality chemicals, and more companies will merge to form larger and fewer multinationals.

The most significant aspects of this growth are where it will occur and with which substances. According to the OECD Reference Scenario[1], while OECD countries will remain the largest chemical producers and consumers to 2020, the rate of production and consumption will grow much faster in non-OECD countries. Over this period, there will be a higher growth rate within OECD countries for speciality and life science chemicals - both of which rely on constant innovation - than for high volume basic chemicals, and this will be accompanied by a shift of production of the more mature basic chemicals to non-OECD countries. With the increasing scale and growth of the global chemicals industry, together with continuing globalisation and greater competitiveness, the current trend toward greater consolidation - leading to fewer and larger multinational producers - is expected to continue.

Environment, health and safety impacts

There is a potential for a negative impact at every stage of chemical production and product use.

Over the entire life of a chemical product (from "cradle to grave") there is a potential for a negative impact on man and the environment. First, as a user of raw materials (*e.g.* natural gas, coal and coke, minerals, fuel oil, liquefied petroleum gas) as a source for energy and feedstocks, the chemicals industry can impact on the supply of non-renewable resources. And, as these materials are in general based on hydrocarbons, their combustion can lead to emissions of carbon dioxide (CO_2) - a greenhouse gas - and volatile organic compounds (VOCs), as well as nitrogen oxides (NO_x) which contribute to the formation of tropospheric ozone or "smog". Processing the raw materials and feedstocks can result in the release of hazardous pollutants to the environment (*e.g.* benzene emitted from a factory) as can their actual use, either by other industries or consumers (*e.g.* benzene in petrol emitted during fuelling of automobiles). Finally, hazardous waste can be generated by the chemicals industry as a by-product of manufacturing and from products which work their way through the supply chain and are eventually disposed of after final use.

1. The Reference Scenario was developed for the OECD *Environmental Outlook* report using the OECD JOBS model and the PoleStar Framework of the Stockholm Environment Institute - Boston. For more information on the assumptions used in the Reference Scenario and the specifications of the modelling exercise, please see Annex 2 of the *OECD Environmental Outlook* (2001a). An excerpt of this is given in Annex 22 to this Report.

Global CO_2 emissions from the chemicals industry are a small part of total CO_2 emissions, but these are projected to increase in the future; emissions from the chemicals industry in OECD countries have stabilised.

The chemicals industry is a major energy user (7% of world energy use in 1998), and yet it contributes only 4% of overall emissions of CO_2 from fossil fuel combustion. However, when compared to other industries (*e.g.* pulp and paper contributes just 1%), the chemicals industry in OECD countries is a major industrial emitter of CO_2. Over the last 15 years, it has nonetheless made important energy efficiency gains, resulting in a stabilisation of CO_2 emissions at a time when production has been increasing. But, according to the Reference Scenario, global chemicals industry emissions are projected to increase in the future, primarily because of growing chemicals production in non-OECD countries which use less energy-efficient technology and are more reliant on coal as a fuel. However, if greater energy efficiency gains are achieved in the chemicals industry, CO_2 may increase at slower rates or continue to stabilise in OECD countries.

Consumption of water is large compared to other industries, but not compared to agriculture.

Another major raw material used by the chemicals industry is water. Compared to all other manufacturing industries, the chemicals industry in OECD countries is the largest consumer of water; however, agriculture is a much larger user of water than all manufacturing industries put together.

Releases of known hazardous pollutants from the chemicals industry are probably declining, but the chemicals industry still discharges large quantities of chemicals to air and water.

Overall, the chemicals industry in OECD countries has made significant progress in reducing releases of pollutants to the environment that result from manufacturing processes. Although there are no consolidated data on emissions of known hazardous substances across OECD countries, it is probable that, overall, such releases from the chemicals industry in these countries are declining. Over the last two decades, the industry may have greatly reduced its releases of hazardous substances per unit of output but, compared to other industrial sectors (*e.g.* electronics, automobile, textiles), it still ranks high today in the intensity of the toxic chemicals and bioaccumulative metals it releases to air and land in terms of weight of emissions per production output. The situation on releases in non-OECD countries is unclear since no past trends data are available.

Releases of substances that promote the formation of smog and acid rain and the generation of hazardous waste are also declining,..

Little global data are available on the total contribution by the chemicals industry in OECD countries to the release of substances which promote the formation of tropospheric ozone (VOCs, NOx) and acid rain (SOx) and the generation of hazardous waste. However, reported data suggest that emissions from the chemicals industry are generally decreasing due to technological changes that are influencing energy use and the operation of chemical plants. Since the adoption of the Montreal Protocol in 1987, tremendous progress has been made in phasing out the production and consumption of chemicals that deplete the stratospheric ozone layer (*e.g.* CFCs).

...but comparatively little information exists on hazardous chemicals sold in commerce and used in countless products.

With respect to the thousands of chemicals that are sold or used in products today, limited information exists on the volumes released to the environment, the targets of exposure and the toxic properties. This means that there are potentially many chemicals whose risks are neither being evaluated nor managed because the necessary information to do so is not available.

Environment, health and safety policies

A wide range of policies is used for managing impacts from the production and use of chemical products.

Over the years, policies have been designed to protect man and the environment from both the hazardous emissions released during the production of chemicals and the risks posed by chemicals which are manufactured by the chemicals industry and contained in consumer products. Policies controlling emissions to air, water and soil by facilities are similar to those in place for other industries (*e.g.* emissions reporting, emission limits, emission rates permitting, waste management). The industry is also subject to policies aimed at managing risks posed by the chemicals themselves (*e.g.* collection and assessment of data on hazard and exposure, material safety data sheets, labelling, marketing and use restrictions). Governments have used a mix of policy instruments (*i.e.* regulatory, economic and voluntary) to work toward the objective of ensuring the chemicals industry and the chemicals it makes are safe for man and the environment.

Governments and companies have adopted environmental programmes with community and worker right to know principles.

Good and widely available information is the critical foundation of any chemical management policy. Over the last ten years, on their own initiative or in response to increasing interest from non-governmental organisations, more and more governments have brought the public (including workers) into discussions about better ways to manage risks. Many governments (and companies) in OECD countries have adopted environmental programmes which incorporate the principles of community and worker right-to-know.

Many governments are turning to emission registers for collecting and disseminating data on releases from production.

One tool that is increasingly being used to provide data and information to the public about known hazardous releases to air, water and soil, in addition to off-site transfers, is a Pollutant Release and Transfer Register (PRTR) which can identify areas of policy need, set priorities for investigating the need for risk reduction and drive emission reductions.

For products, sufficient information exists for new industrial chemicals and pesticides, but not for the far greater number of existing chemicals.

With respect to chemicals produced by the chemicals industry, all OECD governments follow a similar process. First, a government collects information on specific chemicals from environmental monitoring equipment, literature and industry (*e.g.* exposure estimates, animal test data, environmental or health effects data predicted by models). Based on this information, the government can determine what actions, if any, are needed to manage the risks posed by the substances. For new chemicals and pesticides, governments collect and assess information from a prospective manufacturer before a chemical is placed on the market. Unlike new chemicals, the large number of existing industrial chemicals already on the market - and

the general lack or transparency of information on them - pose a primary environmental and health challenge for the industry and regulators. Current efforts to fill this information gap have focused primarily on high production chemicals, with limited success to date.

Holistic/lifecycle assessment and management approaches are being used to integrate production and product policies,..

Historically, most of the management approaches used for controlling emissions during production have dealt with "end-of-pipe" solutions. Recently, governments and industry have been considering more holistic approaches to minimise impacts on health and the environment throughout the lifecycle of a product - from raw material use to final disposal - by designing more environmentally benign chemicals and adopting integrated product policies, including extended producer responsibility.

...and this means also involving small and medium sized companies in discussions on chemical safety.

One necessary input to the lifecycle assessment and management of a chemical is the involvement of all the companies who make, process, export/import or use the chemical, including, where feasible, small and medium sized enterprises (SMEs). As a significant number of chemicals are produced by SMEs, such companies can contribute to the overall impact on man and the environment. However, governments often have only limited interactions with SMEs, and the companies, in turn, are often not very involved in the discussions on chemical safety. Consideration needs to be given to engaging such firms more in the development and implementation of chemical safety policies, but in a way that does not impose a disproportionate burden on them relative to the benefits that such an approach might bring.

Over the last three decades, the management of chemicals has taken on international dimensions...

With more and more trade in chemical products and the growing recognition that pollutants travel across national borders, the last three decades have seen an increase in international efforts by governments to co-ordinate the management of chemicals. Overall direction for this work was provided by the 1992 United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro when it adopted Chapter 19 of Agenda 21. This chapter calls for, among other things, accelerating international work on the assessment of chemical risks, harmonization of classification and labelling of chemicals, establishing risk reduction programmes and strengthening national capacities for managing chemicals. As a follow-up to UNCED, the Intergovernmental Forum on Chemical Safety (IFCS) was created to integrate and consolidate national and international efforts to manage chemicals safety. At the 2000 meeting of the IFCS (Bahia, Brazil), the Forum adopted new Priorities for Action for beyond 2000.

... and structures have been set up to co-ordinate this work.

Inter-governmental organisations with substantial work programmes in the field of chemical safety - UNEP, ILO, FAO, WHO, UNIDO, UNITAR and OECD - created the Inter Organisation Programme for the Sound Management of Chemicals (IOMC) to co-ordinate and foster joint planning of their relevant activities. This supports effective implementation of Chapter 19 without duplication.

The OECD assists Member countries' efforts to protect human health and the environment, while at the same time making chemical policies which are transparent, efficient, and do not lead to distortions in trade.

Since the late 1970s, the OECD Chemicals Programme has aimed to assist OECD countries' efforts to protect human health and the environment through improving chemical safety, making chemical control policies more transparent and efficient, and preventing unnecessary distortions in the trade of chemicals and chemical products. Under OECD's system of *Mutual Acceptance of Data*, countries have agreed that when chemical safety tests are carried out in one country in accordance with OECD Test Guidelines and Principles of Good Laboratory Practice, the other OECD countries will accept the data for assessment purposes. Not only does this save the expense of duplicative testing of products marketed in more than one country, it also reduces the number of animals needed for such tests. OECD governments and industry are also working to minimise, as much as possible, the use and suffering of animals by developing alternative testing methods and encouraging the use of other sources of information (*e.g.* quantitative structure activity relationship models that predict the properties of a chemical substance based on its structure).

Through these and sharing the burden of work,..

By working together, OECD governments and industry also are "sharing the burden" of testing and assessing high production volume chemicals, pesticides and, most recently, new chemicals. If each were to do this alone, there would be an enormous duplication of effort, excessive animal testing, and an extended waiting period before results become available. OECD has also assisted countries in finding ways to share the work involved in the scientific review of registering and re-registering pesticides.

...governments and industry continue to save an estimated US$46 million per year.

For OECD governments and industry, the results of the work done by the OECD on chemicals, have reduced barriers to trade and saved time and money, estimated in 1998 at US$46 million per year.

Challenges

Over the last three decades, much has been accomplished but more needs to be done,..

Over the last three decades, many essential elements of good chemical safety policy have been developed and used both by countries and through international co-operation. This has included reducing emissions of hazardous chemicals during production, keeping unsafe new chemicals from entering the market, developing harmonized methods for safety testing and ensuring test quality to avoid duplicative testing, and discouraging non-tariff barriers to trade. Nonetheless, further effort is needed.

...particularly with respect to the lack of data on existing chemicals.

The current gaps in knowledge about the characteristics, effects and exposure patterns of existing chemicals must be filled. Given the large knowledge gaps about chemicals on the market, it is important to generate and assess information regarding their potential risks by means of appropriate legal and regulatory instruments, voluntary agreements and economic incentives. A scientific, rules-based approach requires reliable information on effects and exposure as the basis for risk management decisions; where such information is not available, more and more countries may take a precautionary approach.

In addition, as the industry undergoes profound change over the next 20 years, new policies will be needed.

Furthermore, **as the chemicals industry undergoes significant changes in terms of what it produces, how and where, there is a need to examine whether current policies will be appropriate for the world 20 years from now**, in which:

- Global output will be 85% higher than in 1995 according to the Reference Scenario, and non-OECD countries will be greater contributors to this production;
- The output in OECD countries will be primarily speciality and life science chemicals, with the non-OECD countries leading in production of high volume basic chemicals; and
- There will be fewer and larger multinational producers.

Possible new approaches include:

Possible new approaches

Given the expected future development of the industry and some of the shortcomings of current policies, the OECD expects three main approaches to evolve.

a greater focus on chemical products;

One, there will be an increased focus on products made with chemicals. This would include, among other things, improving the knowledge base for the design of safe chemicals, a better evaluation of the potential risks resulting from the release of chemicals from products, balancing the efficacy of the product with its overall environmental and health impacts at all stages (*e.g.* using integrated product policies), and replacing hazardous products with less hazardous ones.

more involvement of all stakeholders;

Two, there will be greater involvement of all stakeholders in the chemical safety assessment and management process, with some taking on more responsibility than today.

full responsibility for industry in generating data and a bigger role in assessing data and managing chemicals;

Industry has a greater role to play in providing and assessing data, and in managing chemicals. To help fill the information gap on existing chemicals, procedures could be developed to give industry full responsibility for generating all the necessary data on all chemicals on the market (*i.e.* more than just for high production volume chemicals). Industry could also assume a greater role in preparing assessment reports (based on guidance developed by governments with involvement of all stakeholders) that governments would then make

widely available. Industry should also be obliged to provide information on the uses of the chemicals they produce, not only so that they can be managed better, but also to help set priorities for assessment. Furthermore, the chemical-by-chemical approach to testing, assessment and management needs to be replaced - or at least supplemented - by a framework for consideration of groups or clusters of chemicals that are related by their structure, use or other parameters.

more participation of workers and the public in chemical safety discussions and wider dissemination of data; and

Workers and the public must take a more active role in monitoring and contributing to chemical safety management discussions. To facilitate this, good data from industry on health and environmental impacts must be made more widely available. Policies need to be established to ensure that this information is reliable, and presented in a way that is useful to all potential users for decision-making, including workers, the general public and non-OECD countries. Further, governments and industry should work toward educating the public with respect to chemical safety and, where feasible, provide pubic interest groups with resources that would allow them to play an equitable role in policy discussions.

a greater focus on the chemical safety infrastructure in non-OECD countries.

Three, there needs to be a greater focus on the chemical safety infrastructure in non-OECD countries as the production and use of chemicals become even more wide-spread. This would involve supporting the development of chemical safety regimes in non-OECD countries - for instance by encouraging the participation of these countries in OECD activities - and, if necessary, closer international co-operation to develop efficient international information exchange and control systems. The chemicals industry should also be encouraged to implement the best environmental practices wherever it operates.

2. INTRODUCTION

Chemicals produced by the chemicals industry are used to make virtually every man-made product and play an important role in the everyday life of people around the world. Such products can protect crops and increase yields, prevent and cure disease, provide insulation to reduce energy use and offer countless other benefits that make life better for people.

The chemicals industry - which includes basic and speciality chemicals, consumer care products, agrochemicals and pharmaceuticals - is also a major economic force which employs millions of people around the world, and generates billions of dollars in shareholder value and tax revenues for governments. It is more than twice the size of the world market for telecommunications equipment and services, and accounts for about 7% of global income and 9% of international trade (WEC, 1995).

As with other large manufacturing industries, the chemicals industry can also have a negative impact on human health and the environment when the production and use of chemicals are not managed responsibly. From the use of non-renewable resources for fuel and feedstocks (*e.g.* oil and gas), to the release of pollutants from factories during production, to the disposal of final products that contain hazardous waste, each stage of the lifecycle of a product produced by the chemicals industry can affect man and the environment.

Although the impacts from hazardous chemicals produced by the chemicals industry are complex, and sometimes open to debate, some negative effects have been well documented, as can be seen from the following examples. Dichlorodiphenyl trichloroethane (DDT), an insecticide, was developed to control a number of insect pests and is widely used in tropical countries for disease vector control (malaria, yellow fever). But it has been demonstrated that it can cause reproductive failure in eagles and other birds due to the thinning of eggshells. Certain polychlorinated biphenyls (PCBs) are relatively fire resistant and are employed primarily as cooling and insulating fluids in industrial transformers and capacitors. However, PCBs are persistent in the environment and can lead to reproductive effects in some mammalian species. The vinyl chloride monomer in polyvinyl chloride (PVC) - that is used for a range of products such as pipes, films, bottles, floors and walls - has been shown to cause cancer (EEA, 1995). Phosphates in washing powders and detergents cause eutrophication of aquatic ecosystems (EEA, 1995).

Endocrine disrupting chemicals are also a concern as they interfere with the normal function of the hormonal systems of humans and animals. These properties have been found in several classes of chemicals released into the environment, such as some insecticides and fungicides, phthalate plasticizers, dioxins and antifouling paints (Royal Society, 2000).

Most recently, concern has been expressed about chemicals which are characterised by persistence in the environment, resistance to degradation, and acute and chronic toxicity. Further, some of these can be transported over long distances through the atmosphere or aquatic systems and pollute areas where they have never even been used.

In addition, there has been a growing focus in countries on investigating the impacts of chemicals on children's health (*e.g.* certain chemicals like lead, mercury and polychlorinated biphenyls which may have harmful and possibly permanent neurological effects on children). A child's nervous system, reproductive organs, and immune system grow and develop rapidly during the first months and years of life. As organ structures develop, vital connections between cells are established. These delicate developmental processes in children may easily and irreversibly be disrupted by toxic environmental substances, such as lead (US EPA, 2000b).

For many other effects, the link with exposure to chemicals may be only suggestive as the effects could be the result of many causes that act together (such as lifestyle, diet, smoking, *etc.*) and additional information may be needed to draw more definitive conclusions.

In the early 1980s government studies revealed that many chemicals on the market had not been sufficiently tested to allow a complete determination of their potential hazards (NAS, 1984). Much effort has been spent over the ensuing years on testing and assessing chemicals, and a significant government/chemicals industry effort is currently underway in OECD to collect information on high production volume chemicals, but there are still some gaps in our knowledge. Given the number of chemicals on the market, questions have been raised as to whether the impacts on man and the environment are a concern, and, if so, what should be done.

To answer these questions, this report attempts to describe the chemicals industry of today and tomorrow, and the environmental impacts that have occurred and may occur in the future. A complete, quantifiable and comprehensive answer with regard to all chemicals and all possible impacts is not possible. By providing information on past and projected developments in the chemicals industry (production, consumption and trade) and environmental policy, this report provides the context for addressing the main issues and suggesting policy options for filling data gaps and tackling other problems.

The chemicals industry is very diverse in terms of production and products, and the types of impacts it can have on man and the environment. This report focuses only on those sectors or impacts which, historically, have been considered by the OECD Environment, Health and Safety Programme (*i.e.* industrial chemicals, biotechnology, and pesticides). Other important issues for examining the chemicals industry - such as impacts from the production of pharmaceuticals, impacts during the transport of chemicals, and impacts on workers - are discussed briefly.

3. CHEMICALS INDUSTRY TRENDS AND OUTLOOK

3.1 Description of the industry

The industry as a whole

Companies

One word can describe the chemicals industry: diverse. There is no one typical product or one typical company. Starting with raw materials such as oil, coal, gas, air, water and minerals, the chemicals industry converts these materials into a vast array of substances for use by other chemical companies, other industries and consumers. The chemicals industries of industrialised nations produce a wide variety of chemicals ranging from commodity industrial chemicals used to make other products to speciality chemicals tailored for unique applications. These products can range from large bulk chemicals used to make plastics, to small bottles of cleaning solutions used by households. Many chemicals companies have a large body of technological knowledge in research and process engineering, abundant capital and management capacity, and skilled and technically competent labour forces.

The types of companies involved in producing this vast array of products also vary considerably. Some chemical companies are ranked amongst the largest industrial companies in the world - the top ten chemical companies had revenues in the range of US$10-30 billion (Fortune, 2000). These firms employ many thousands of workers (some with over 100,000 employees) and they have multiple manufacturing sites located throughout the world. Other chemical companies may make only a few products at one site and are relatively small in size. Companies with fewer than 50 employees and less than US$50 million in annual sales make 95% of the 50,000 chemicals produced in the US (SOCMA, 2000).

The chemicals industry is also a major employer, with over 10 million people employed worldwide (CMA, 1999a). However, as the industry has become more productive and production processes have become highly automated, world employment levels in the industry have fallen 7.5% over the last ten years.

Given the complexity of the processes and the constant need for innovation, the chemicals industry is research intensive. Most companies allot 4 to 6% of their annual sales for R&D (CMA, 1999a), although the percentage of revenue spent on research varies from one branch to another. Companies specialising in large-volume basic chemicals that have been widely used for many years spend less, whereas competition in the newer sectors can be met only by intensive research efforts. Research costs are greatest for the life sciences companies and lowest for producers of commodity chemicals.

Manufacturing facilities

Just as chemical companies vary in size, so too do their production facilities. Large companies may have "world-class" plants that can be highly automated and produce or process enormous volumes of chemical products each year. For instance, today's ethylene cracker units - used by the petrochemical industry to convert naphtha, natural gas or oil to ethylene - have a capacity of up to 1.5 billion lb./year (Wittcoff and Reuben, 1996). Some chemical plants are almost self-contained cities with large numbers of workers, enormous amounts of equipment (including their own power supply) all spread over a wide area. The Bayer chemical company's largest plant, located in Leverkusen, Germany, covers an area of approximately 3.4 square kilometres and is made up of some 600 buildings. It is one of the world's biggest and most diversified sites for the manufacture of organic and inorganic products, pharmaceuticals, dyestuffs, polyurethanes and rubber (Bayer, 2000). The Dow chemical company's Texas operations, located in Freeport, Texas, is made up of three major complexes, employs approximately 5,200 people, and manages the production of some 40 billion pounds of products manufactured annually by 75 individual production plants (Dow, 2001).

But again, there is the other end of the scale. Small, one-plant facilities continue to play an important role in the production of chemicals. As can be seen in Table 1, more than half of the chemicals industry sites in Japan employ less than 30 workers. Similarly, in the European Union, 70% of the firms have nine or fewer employees (see Table 2), yet they make up only 3% of total sales. Small facilities play an important role in the production of fine chemicals, the raw materials for pharmaceuticals and some crop protection and other products. They are also involved in the production of adhesives, coatings, institutional and industrial cleaning compounds, fertilisers, some personal care products and many other speciality chemicals.

Table 1
Chemicals industry in Japan

Number of employees at each site	Total sites	Total employees	Sales (million yen)
4-29	3170	42,744	1,516,604
≥30	2256	340,070	21,706,666

Source: Japan's Census of Manufactures 1998 (MITI, 2000)

Table 2
Chemicals industry in the European Union

Number of employees at each site	1-9	10-99	100-249	250-499	500+
Sales (%)	3	10	10	14	63
Number (%)	70	22	4	2	2

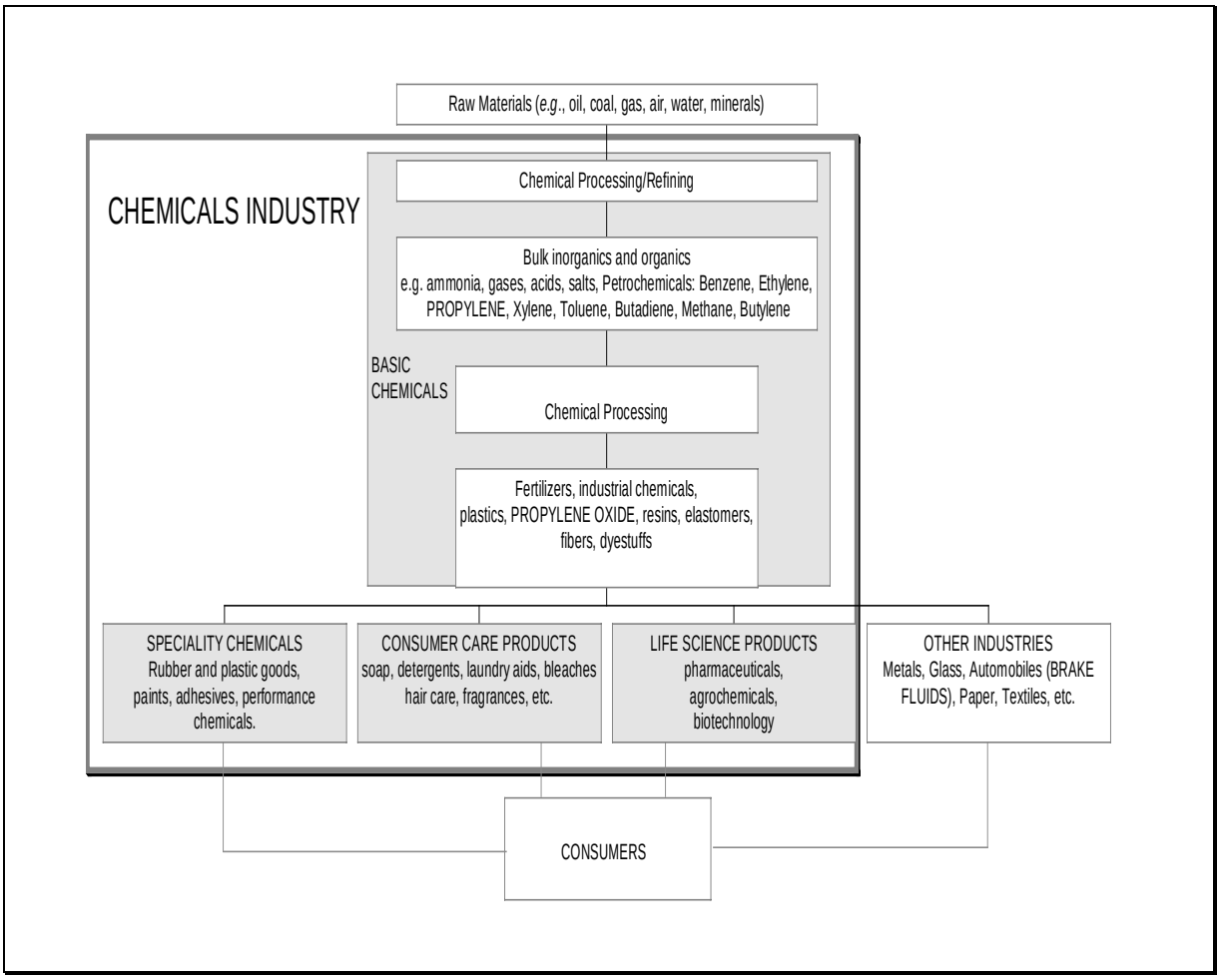
Source: UNECE The Chemical Industry in 1999, Annual Review (UNECE,1999)

Production processes

The starting point for the chemicals industry is raw materials such as oil, coal, natural gas, air, water and minerals (see Figure 1). Like a tree, which starts as one trunk and then expands to multiple branches, the chemicals industry uses these few raw materials to produce tens of thousands of different chemical substances. The raw materials are refined to make primary or first-level chemicals (*e.g.* benzene, ethylene, propylene) which are then further processed to produce second-level chemicals (*e.g.* dodecylbenzene, ethylene oxide, propylene oxide), and so on. These products are most often end products only as regards the chemicals industry itself; a chief characteristic of the industry is

that its products nearly always require further processing before reaching the ultimate consumer. Thus, paradoxically, the chemicals industry is its own best customer. An average chemical product is passed from factory to factory (or to various units in the same factory) several times before it emerges from the chemicals industry to other industries and consumers.

Figure 1
Overview of the chemicals (basic, speciality, consumer care, life sciences) and related industries



Source: EEA, 1995 and Swift, 1999, modified by the OECD

Regardless of size, each plant operation follows a similar production chain. First, to start the process, raw materials or feedstocks (*e.g.* propylene oxide) are brought to the plant. They can be shipped to the plant *via* tanker/barge, rail, pipeline or truck, or they can be produced by the same company but at another part of the plant. Following processing, the resultant chemical can be packaged and shipped to another part of the plant, to another chemical company, to another industry (*e.g.* automobiles, textiles, paper), or directly to consumers (*e.g.* as brake fluid, antifreeze, cosmetics, tapes).

The sectors of the industry

While the sectors within the chemicals industry[2] shown in Figure 1 share certain similarities, there are distinct differences between each sector. Figure 1 divides the chemicals industry into four groupings: basic chemicals, speciality chemicals, consumer care products, and life science products. Keeping in mind that the lines between them can become somewhat blurred, the general characteristics of each are described below.

Basic chemicals (or commodity chemicals): Basic chemicals represent a mature market, which is illustrated by the fact that 46 of the top 50 highest volume chemicals in 1977 were still in the top 50 in 1993. Not only has the composition of this group remained largely unchanged, but also the rank order in production volume has not varied much (Wittcoff and Reuben, 1996). The industry is characterised by large plants, mainly using continuous - as compared to batch - operations, with high energy consumption, low profit margins, and a high degree of cyclicality over the business cycle due to fluctuations in capacity utilisation and feedstocks (or raw materials). Markets for basic chemicals are primarily in other basic chemicals, speciality chemicals, and other chemical products, as well as in other manufactured goods (textiles, automobiles, appliances, furniture, *etc.*) or in the processing applications (pulp and paper, oil refining, aluminium processing, *etc*.) (Swift, 1999).

Speciality chemicals: These chemical substances (*e.g.* adhesives and sealants, catalysts, coatings, electronic chemicals, plastic additives), which are derived from basic chemicals, are more technologically advanced products than basic chemicals. They are manufactured in lower volumes than basic chemicals, give higher profit margins and have less cyclicality in their business cycle. Speciality chemical products have a higher value-added because they cannot easily be duplicated by other producers or are shielded from competition by patents. Although dedicated and continuous operations are typical, there are also a growing number of plants that are general-purpose synthesis operations.

Life science products: These include pharmaceuticals, products for crop protection and products of modern biotechnology. Plants generally use batch-oriented synthesis or formulating operations where quality control and a clean environment are critical. Technological advantages are extremely important and R&D spending for this sector is the highest among all industries.

Consumer care products: This includes soap, detergents, bleaches, laundry aids, hair care products, skin care products, fragrances, *etc.* Consumer care products is one of the oldest segments of the chemistry business. These products are formulated products, employing what is often simple chemistry but featuring a high degree of differentiation along branding lines. Research and development expenses are rising and many of these products are becoming high-tech in nature. Consumer care products are generally formulated in batch-type operations, although some products (*e.g.* detergents) are manufactured in large dedicated plants. Formulating involves mixing, dispersing, and filling equipment rather than reactors for chemical conversions.

3.2 Production, consumption and trade

From an economic standpoint, there are many ways to gauge how the chemicals industry has done recently, and is expected to do in the future. This portion of the report focuses on three main

2. There is no single definition of the chemicals industry for statistical purposes, and the industry sectors included in the various sources referenced in this report may not be strictly comparable. This is unavoidable, but does not affect the principle findings reported here. Definitions from some of the main sources used are found in Annex 1.

indicators. The first is *production* (or output) which indicates the volume of chemicals manufactured in any one year. As not all of the amount produced is consumed in any given year (excess production going to storage), *consumption* (also called demand) gives an indication of how much is actually being used. Finally, it is important to consider *trade* which shows how much of the amount produced leaves a country, and how much of the amount consumed comes from another country.

As will be seen below, the amount of production, consumption and trade of chemical products has been steadily rising over the years and will continue to grow over the next 20 years. Most significantly, these amounts are growing at a faster rate in non-OECD countries than in OECD countries.

Past and current trends

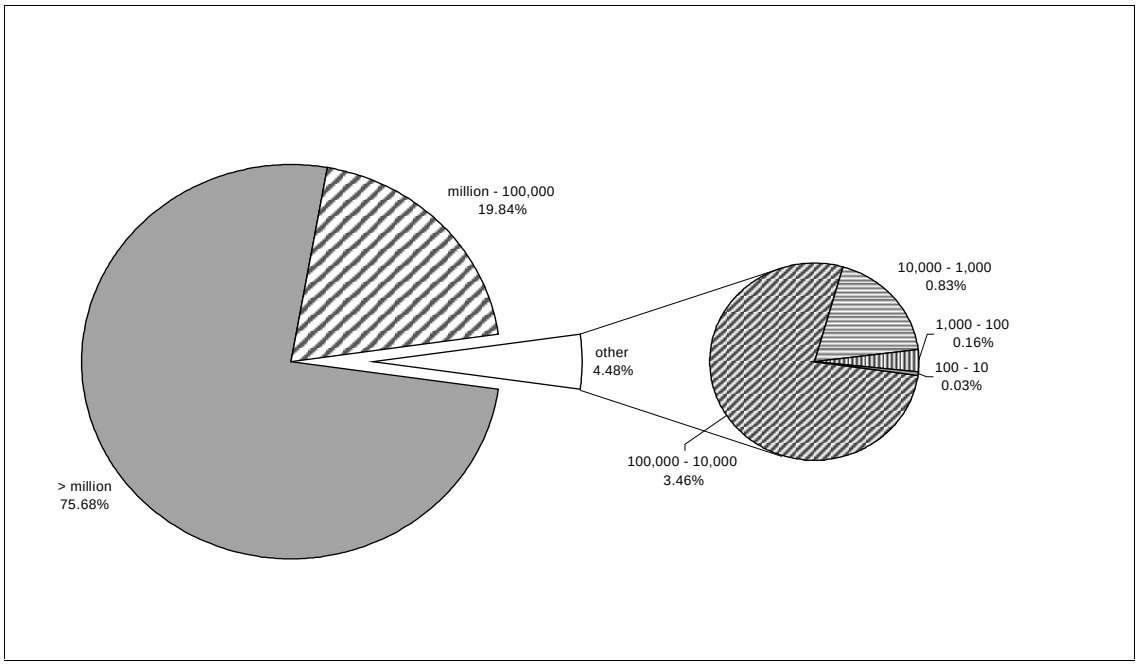
Production in OECD countries

The global chemicals industry today produces tens of thousands of chemicals. In 1998, shipments from OECD countries were worth US$1201 billion. Chemical companies sell these substances, as is, to other industries or consumers, or to other chemical companies. These substances can, in turn, be mixed by the chemicals industry and sold as preparations (*i.e.* a mixture of two or more substances which do not react with each other), or chemicals industry customers can create these preparations. It is estimated that there are between one and two million preparations in commerce within the European Union (Donkers, 2000).

With the constant shift of demand from customers, some chemicals are no longer in demand and are taken off the market each year, while new chemicals are introduced. It is estimated that approximately 200 to 300 new chemicals are produced in significant quantities annually and added to the market (OECD, 1998a).

While there may be tens of thousands of chemicals currently in commerce, it is certain that many are not produced in large volume. Within the European Union, only 2,500 are produced in quantities of over 1000 tonnes per year. Typically, the chemicals produced in biggest quantities tend to be basic chemicals. While some chemicals are produced in huge volumes worldwide - in 1997, the worldwide consumption of ethylene dichloride (a basic chemical) was 38 million tonnes (SRI International, 2000) - many others are produced in very small amounts. Figure 2 below shows that, of the *total* production volume of chemicals within the EU, 75% of this volume concerns chemicals that are produced in volumes greater than 1 million tonnes/year; whereas chemicals produced in volumes less than 10,000 tonnes/year represent only slightly more than 1% of the total volume of chemicals on the market. The Japanese chemicals industry shows a similar breakdown for production in Japan (see Table 3).

Figure 2
Distribution of existing chemical substances in the EU according to volume (tonnes/year)



Source: Theins, N. (2000)

Table 3
Existing chemical substances in percentage by number of substances and volume within the European Union and Japan

Tonnes/year	by number in %		by volume in %	
	EU	JAPAN*	EU	JAPAN*
>1 million	1.34	0.7	75.68	77.9
>100,000 to 1 million	3.5	2.3	19.84	16.2
>10,000 to 100,000	6.12	5.8	3.46	4.2
>1,000 to 10,000	14.73	16.0	0.83	1.3
>100 to 1,000	28.45	32.7	0.16	0.3
>10 to 100	45.86	42.5	0.03	0.0

(EU data provided by the European Commission are unofficial; figures for Japan are estimates provided by the Japanese Ministry of International Trade and Industry)
*These are estimated figures and may not cover all chemicals in Japan.
Source: Theins, N. (2000); Nagata, Y. (2000)

Global expansion of the industry

Beginning in the 1960s, investment by companies in many OECD countries in production facilities in foreign countries and the development of world markets led to a worldwide expansion of the chemicals industry. This was fostered by lower labour costs in non-OECD countries, world economic growth, the reduction of tariffs and other trade barriers, and advances in telecommunication and transportation. The globalisation of investments and markets has spread industry capital

resources, technology and managerial capabilities around the world and resulted in the emergence of multinational chemical companies. Although a number of large companies already had foreign subsidiaries for many years, international investment by American and Western European countries grew at a particularly rapid pace during the 1980s and the 1990s (CMA, 1999a).

In the 1980s, the domestic chemicals industries in many developing countries also began to become global competitors. As these industries in non-OECD countries, which typically make simple basic chemicals such as fertilisers and inorganic commodity chemicals, had only moderate production, they were traditionally export markets for the chemicals industries of developed countries. But today, many are boosting exports and producing other types of products such as speciality chemicals, albeit in small volumes.

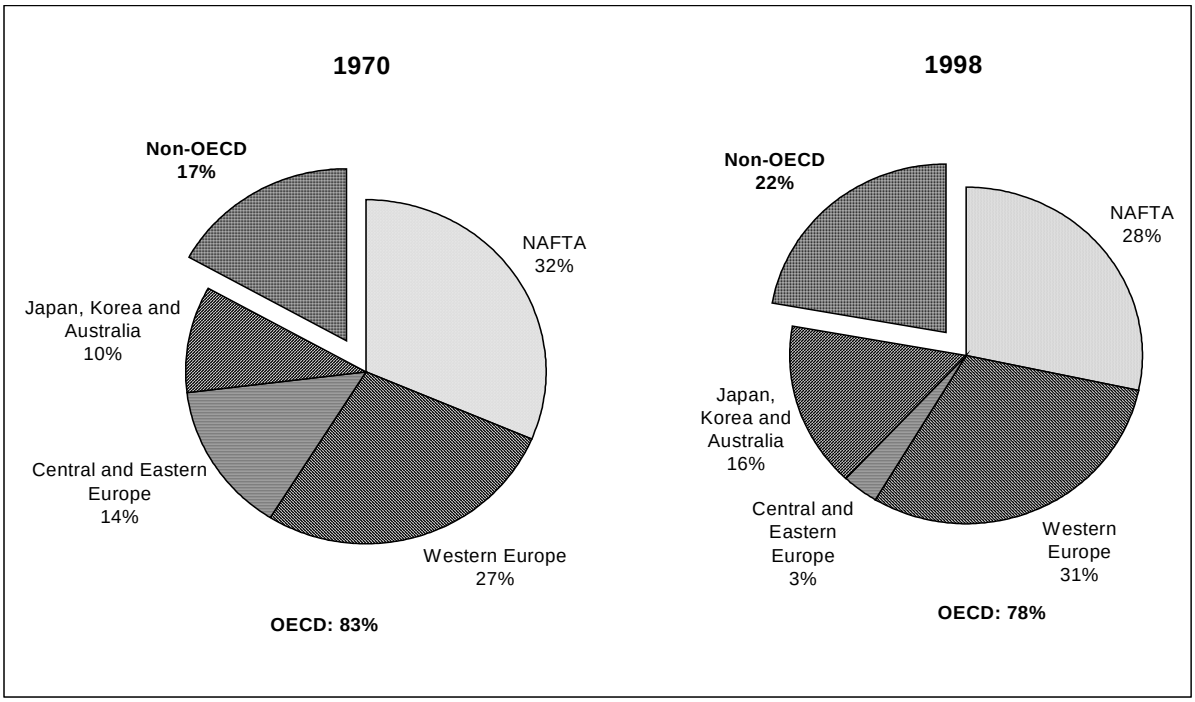
In the wake of the steep rises in oil prices in the 1970s, another opportunity arose for countries with a hitherto insignificant chemicals industry to enter the global market. There was an environment for owners of large gas reserves with limited markets (*e.g.* Saudi Arabia) to convert these resources to petrochemicals (which have a greater value-added than energy use) and to ship them to remote consuming markets to compete with local production (Willems, 2000).

As the markets for chemicals mature in the industrialised world, developing countries offer the greatest growth opportunities either by exports or by investments in production facilities. Investment by chemical companies in facilities in foreign countries has been growing since the 1980s and 1990s and is expected to continue. Such growth in spending by chemical companies in OECD countries is in addition to growth in spending by non-OECD chemical companies in domestic facilities.

Overall global production

Almost every country has a chemicals industry, but the bulk of production is accounted for by a small number of industrialised countries (see Figure 3), with currently approximately 80% of the world's total output being produced by only 16 countries (in decreasing order): US, Japan, Germany, China, France, the UK, Italy, Korea, Brazil, Belgium/Luxembourg, Spain, the Netherlands, Taiwan, Switzerland and Russia (CMA, 1999a). While OECD countries accounted for 78% of world output in 1998, this is 5% less than in 1970.

Figure 3
Percentage share of world chemicals industry output (1970 and 1998)

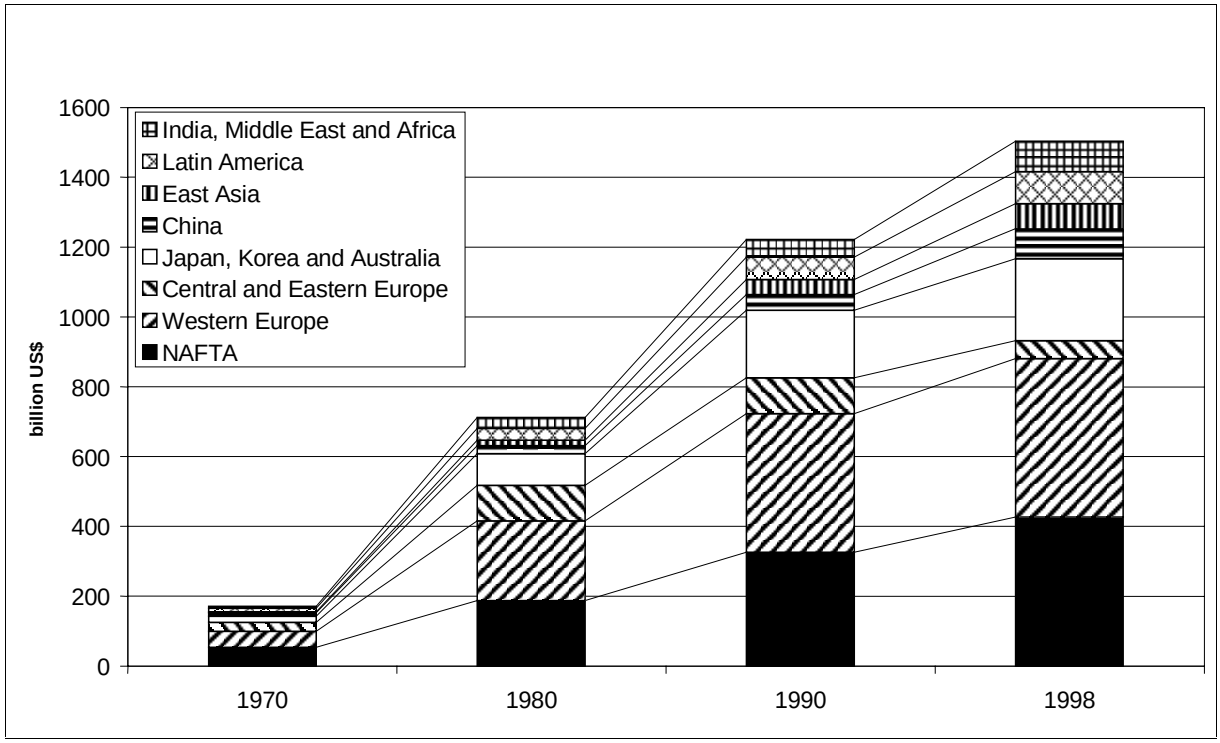


Source: CMA, 1999a (See Annex 2).

One of the most important trends seen in the global chemicals industry since 1970 is its rapid growth. As seen in Figure 4, world chemical output has increased from US$171 billion in 1970 to US$1503 billion in 1998. The US, Western Europe and Japan have dominated chemical production for the last 30 years. However, other countries have at the same time been increasing production and today the industry can legitimately be called "global". Countries such as Korea, China, Taiwan, Saudi Arabia and Canada, with very modest or virtually no chemicals industries 30 years ago, have become major purveyors of chemicals worldwide. Furthermore, the chemicals industry in some of these countries is a significant, if not the most significant, sector in the economy. In Taiwan, for instance, in 1996 the chemicals industry accounted for 30% of manufacturing in that country as opposed to 10% in the US and Western Europe (Wittcoff and Reuben, 1996).

Trends in methanol production (a basic chemical) present a good example. In 1975, 65% of world production of methanol occurred in developed regions, with 35% from the rest of the world. By 1993, only 33% of world methanol production came from the US, Western Europe and Japan, with 67% coming from the rest of the world (CEH, 1995).

Figure 4
Volume of world chemicals industry output (1970, 1980, 1990, 1998)

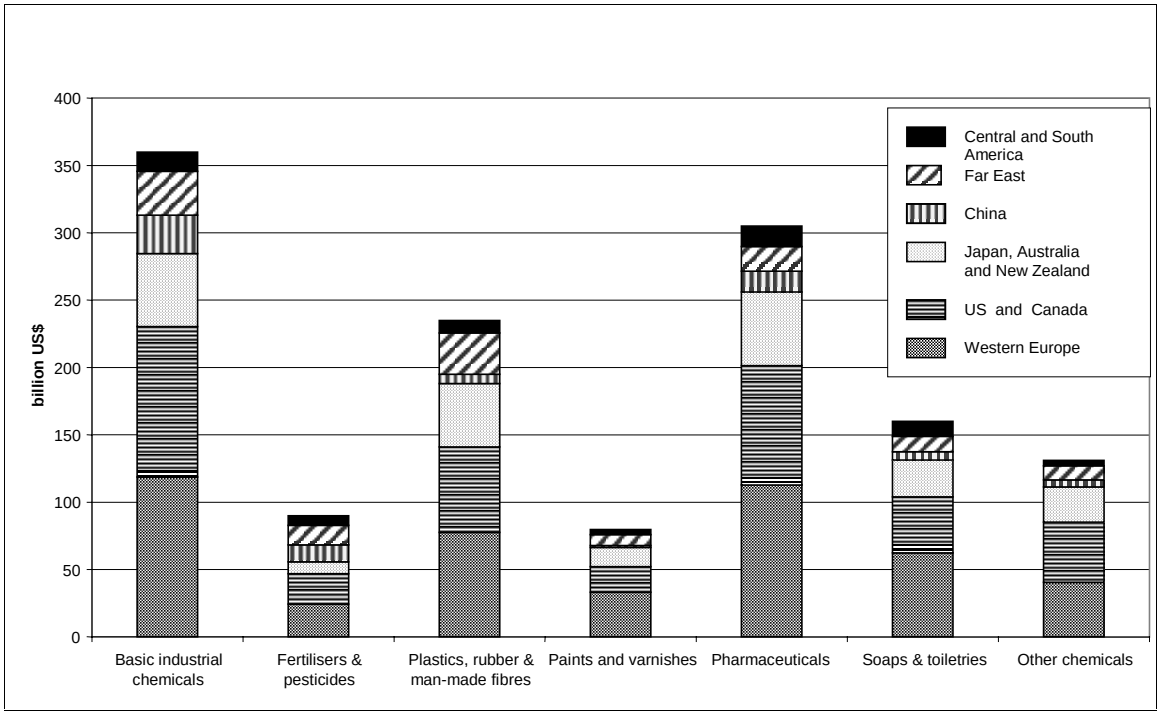


Source: CMA, 1999a (See Annex 2).

Global production by industry sector

Figure 5 shows how the production of chemicals in the various industry sectors is spread around the globe, with production for each sector highest in Western Europe, US/Canada and Japan. As the overall industry volume has been growing, the industry *sectors* that make up this volume have grown at different rates depending on each country.

Figure 5
Chemical sector output estimates in 1996



Source: CIA, 1999 (See Annex 3).

During the period 1986-96, pharmaceuticals was the major growth sector in the chemicals industry in Western Europe, US/Canada and Japan, followed by plastics, rubber and man-made fibres. Basic chemicals production increased most strongly in Japan. The UK Chemical Industries Association (CIA, 1999) believe that if data were available for developing economies during this period, basic chemicals could be expected to be one of the growth leaders in China, and in other areas of the Far East and the Middle East. In these regions there has been massive inward and state investment, tapping into low cost oil and gas feedstocks, using relatively cheap labour and helped by western technology. The Chinese industry has been fuelled by its huge coal reserves and supported by a fast growing economy during the last decade.

In an attempt to avoid fierce price competition from developing countries, many chemical companies in industrialised countries are switching production from basic chemicals to speciality chemicals, life sciences and high value-added products. Reflecting this shift, the chemicals industries of developed countries are based increasingly on technical knowledge, abundant capital, and skilled management and labour. The domestic chemicals industries in developing countries are mostly based on simple chemical products, such as fertilisers and inorganic commodity chemicals, with some also producing small quantities of speciality chemicals and non-proprietary agricultural and pharmaceutical products. Recently, however, several developing countries have begun to establish globally competitive chemicals industries across all sectors.

Established markets in the developed world, especially in Western Europe, North America and Japan, are becoming steadily more sophisticated, and consequently companies are becoming more innovative and more specialised in areas such as biotechnology, electronics and advanced materials (CIA, 1999). Technological developments have also been important in bringing about major changes in some sectors of the chemicals industry. This has particularly been the case with speciality

chemicals, agrochemicals, pharmaceuticals and the food-related industry, where biotechnology is already beginning to play a role. As a result, major restructuring is taking place in the industry. For example, Monsanto shed its chemicals business, spending US$6.5 billion to access agricultural biotechnology expertise and downstream seed markets. Hoechst is splitting off chemical operations and merging its drug and agribusiness with Rhone-Poulenc. Biotechnology is becoming increasingly important in other sectors as well (see Box).

Plastic from plants

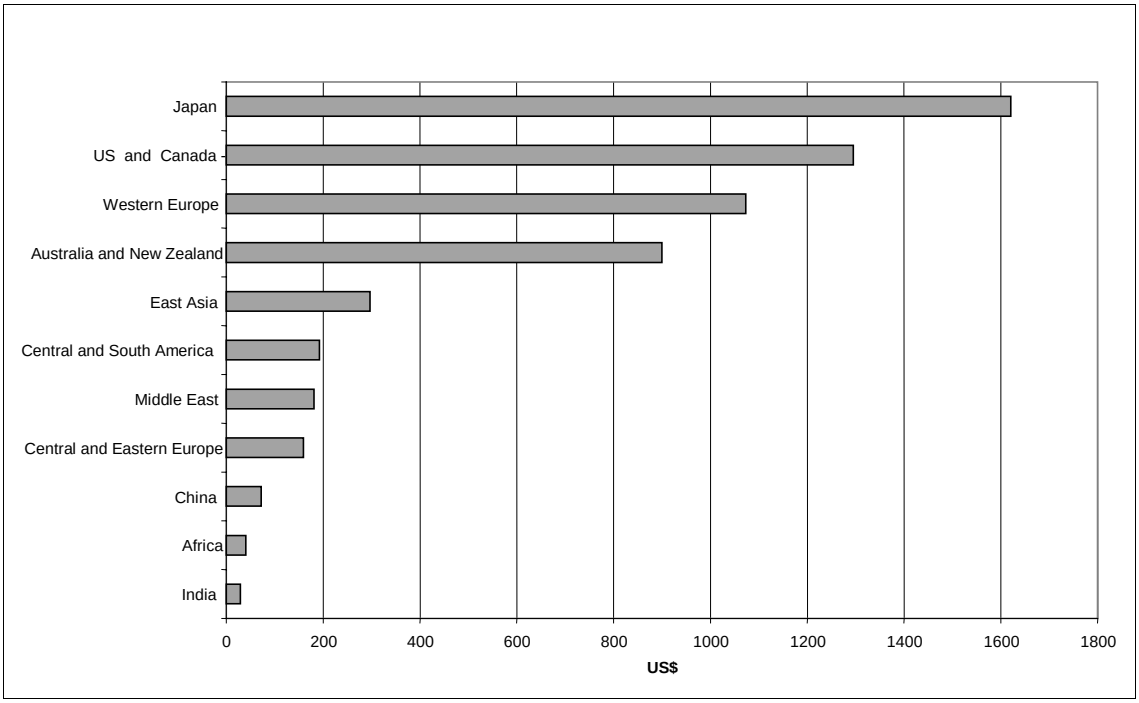
Monsanto announced in September 1999 that it had developed genetically modified plants able to grow plastic. Monsanto had taken genes from plastic-manufacturing bacteria and put them into rape and cress. The carbon atoms, which are incorporated into the plastic, come from CO_2 that the plant takes from the air. The next step is to try to scale the process up to produce reasonable yields. If this proves successful, it could provide a means for producing plastics that does not rely on oil resources. This is just one of the areas where crops might take the place of petrochemical feedstocks. Crops such as oilseed rape, linseed and hemp could form the basis for detergents, fuels, lubricants and textiles. One question that can be posed of course, is the availability of fertile land that can be used for these purposes, instead of serving the food supply. Even though there appears to be a plentiful supply of oil in the medium term, many companies are investigating these areas because of a number of pressures, including environmental taxes.

DuPont has recently commercialised a technology for producing man-made fibres using bio-science (*e.g.* microbes) as opposed to traditional chemistry (*e.g.* hydrocarbon feedstocks).

Global consumption

Not only is production for all the chemical sectors currently higher in OECD countries than in non-OECD countries, the per capita consumption of chemicals in the developed world is also far greater than in the developing world (see Figure 6). This demonstrates the correlation between chemical consumption and GDP *per capita* and suggests that there is tremendous scope for increased consumption of chemicals in the developing world.

Figure 6
Demand for chemicals per capita in 1996

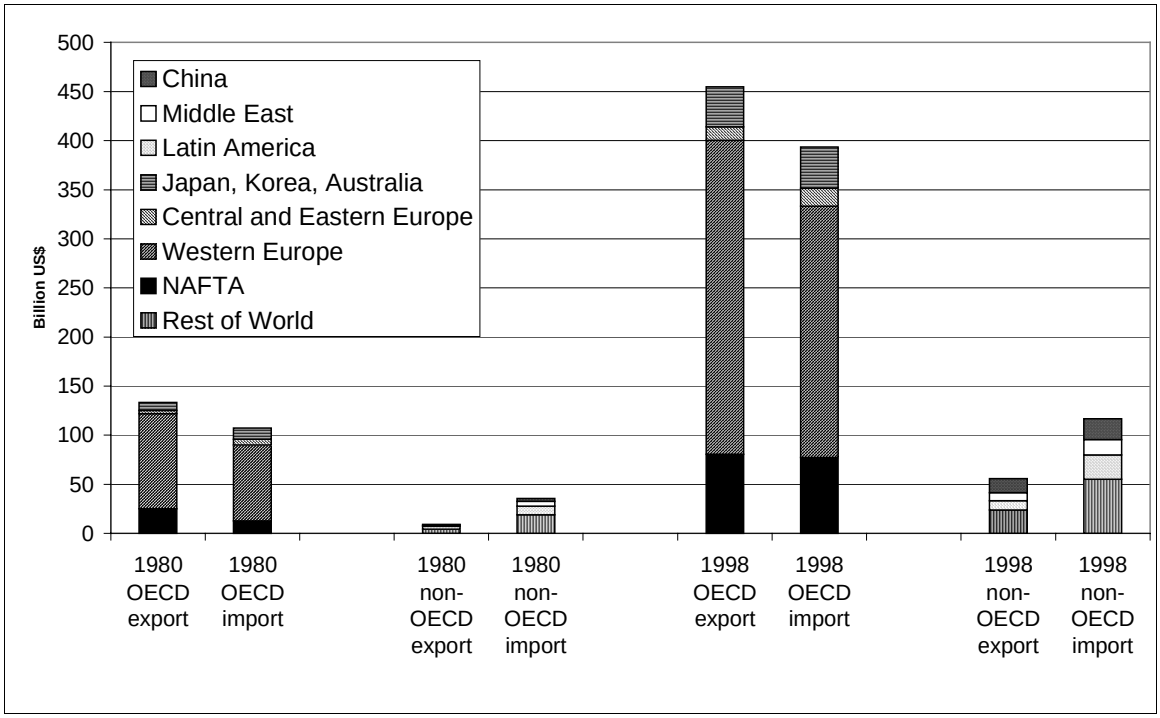


Source: CIA, 1999 (See Annex 4).

Trade

Another important trend in the chemicals industry since the 1970s is an increase in international trade, the industry's post-war development having gone hand-in-hand with trade liberalisation. Trade is currently dominated by OECD countries which have nearly equilibrated trade balances with each other and register trade surpluses with virtually all the other regions of the world (see Figure 7) (CMA, 1999a).

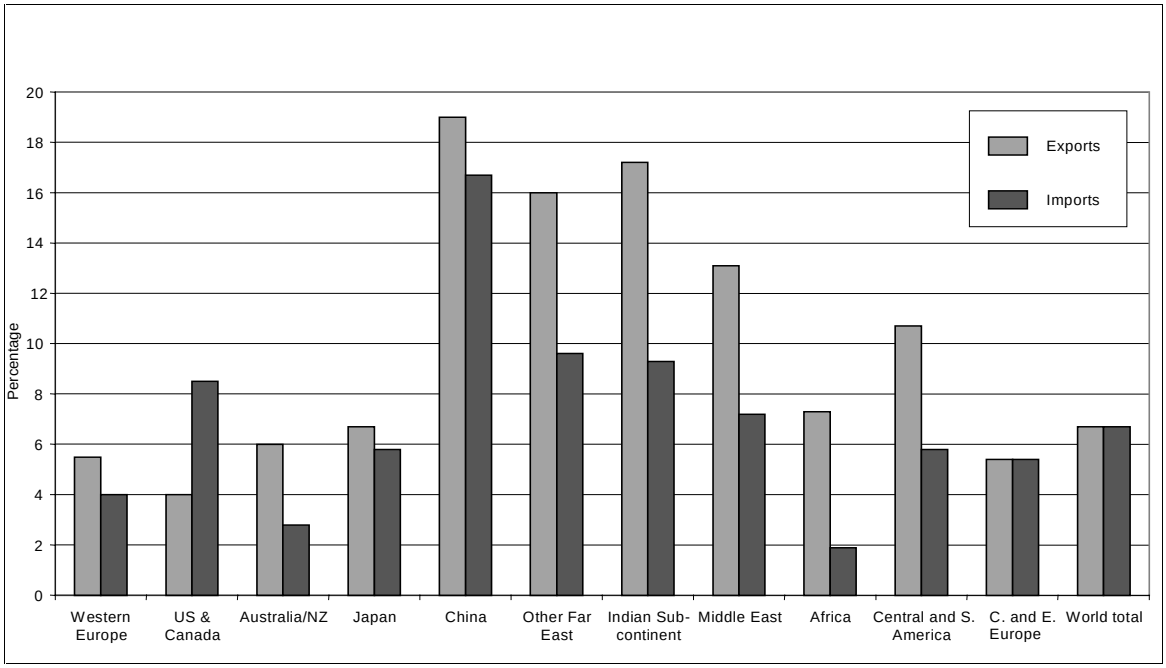
Figure 7
Volume of trade in chemicals (1980 and 1998)



Source: CMA, 1999a (See Annex 5).

Between 1979 and 1996, in each region of the world the chemicals trade grew more than demand and production, with growth in trade volume in developing markets increasing more rapidly than in developed markets (Figure 8). The tremendous growth rate in exports and imports of chemicals from and to non-OECD countries - as compared with the mature markets in OECD countries - represents a major change.

Figure 8
Growth in trade in chemicals between 1979-96 (real terms, % p.a.)



Source: CIA, 1999 (See Annex 4).

Future outlook

Based on past trends and drivers, it is predicted that demand for chemicals will continue to increase, particularly in some of the developing countries. Globalisation of the industry will also continue, with production in non-OECD countries steadily growing. More detailed projections for the industry as a whole and for the different sectors are given below.

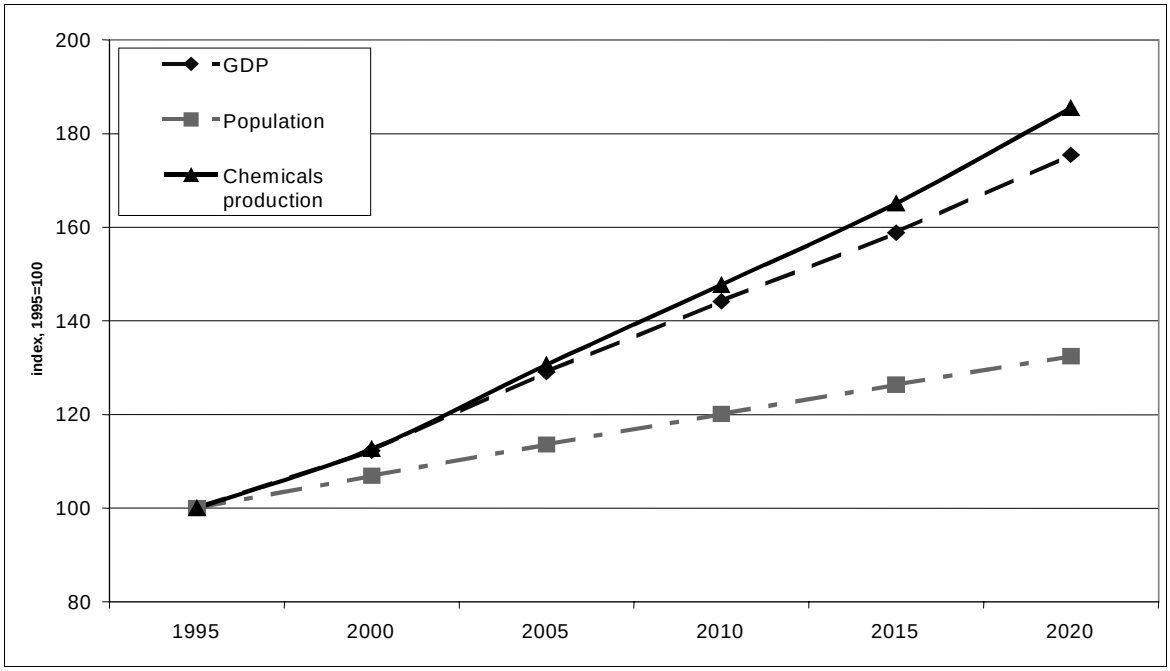
Overall global production

A number of studies have been done projecting future growth in the chemicals industry. In most cases these are up to the year 2010. The UK Chemical Industries Association and the US Chemical Manufacturers Association (CIA, 1999; CMA, 1999b) predict that in 2010, world chemicals output will increase to US$2,360 billion (in 1996 price terms) – an increase of 63% in real terms compared to 1996. The OECD Reference Scenario[3] predicts an even larger total world output (US$3,920 billion), but its starting base in 1996 was also higher. Most important, the OECD Reference Scenario, CIA and CMA predict relatively similar annual growth rates for the global chemicals industry, ranging between 2.6% (Reference Scenario) and 3.5% (CIA).

3. The Reference Scenario was developed for the OECD *Environmental Outlook* report using the OECD JOBS model and the PoleStar Framework of the Stockholm Environment Institute-Boston. For more information on the assumptions used in the Reference Scenario and the specifications of the modelling exercise, please see Annex 2 of the OECD *Environmental Outlook* (2001a). An excerpt of this is given in Annex 22 to this Report.

Over this period, the rate of growth for the chemicals industry will be roughly the same as the rate of growth for the world gross domestic product (see Figure 9). At the same time, however, the world population will grow at a slower rate, which means that global chemical production *per capita* will increase in the future.

Figure 9
Projected growth in chemicals production, world GDP and world population (1995-2020)

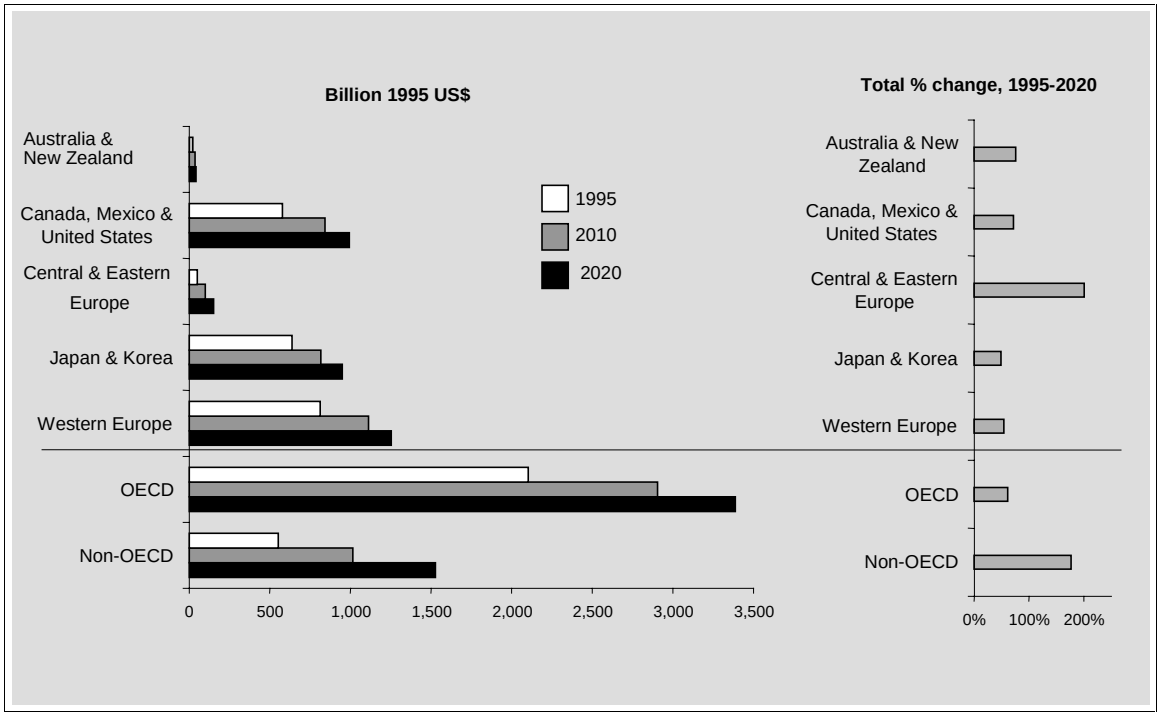


Source: OECD Reference Scenario (See Annex 6).

Geographic distribution of production and consumption

During this period (through 2020), there will also be a shift toward greater chemicals production in non-OECD countries than at present (see Figure 10). While OECD countries will still be the largest chemical producers in 2020 (with 69% of total world production), this is down 10% from 1995 levels.

Figure 10
Projected chemicals production by region (1995-2020)



Source: OECD Reference Scenario (See Annex 6).
Note: These figures include manufacturing of plastics and rubber.

Similarly, total chemicals demand is projected to increase more rapidly in developing than developed regions (China has the highest growth in demand), reflecting higher GDP growth and increasing use of chemicals in these regions. In 2020, the developing world will account for 33% of world chemical demand and 31% of production, compared with 23% and 21% respectively in 1995 (see Annexes 6 and 7).

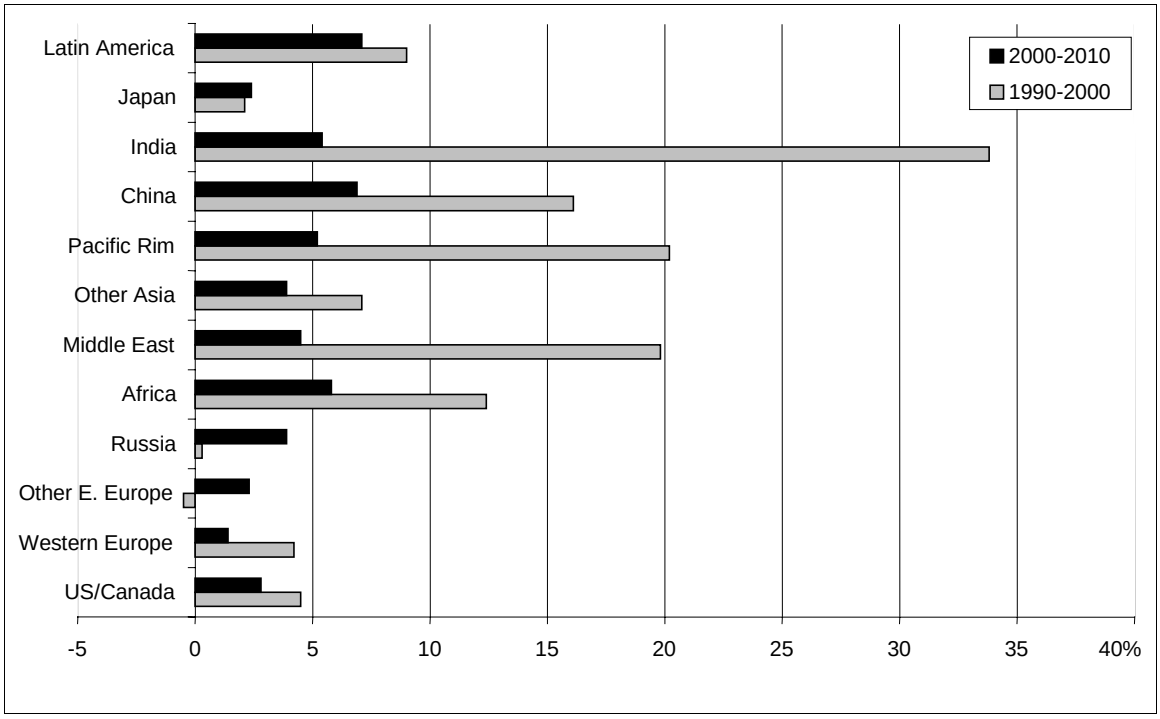
Changes in sectors and products

Little information appears to be available on projections for future growth in the various sectors. Globally, CMA predicts a similar pattern up to 2010 as occurred between 1980-97, that is, growth being led by pharmaceuticals, followed by speciality and "other" chemicals, agricultural chemicals, textile fibres and industrial chemicals (CMA, 1999b). For the US, CMA anticipates that growth over the next ten years will be greatest in the life sciences sector (4.75% *per annum*), followed by speciality chemicals (3.25% *per annum*), consumer products (1.75% *per annum*) and basic chemicals (> 1.25% *per annum*). Economist T. Kevin Swift wrote that: "Even under the most conservative assumptions, life sciences will, by the year 2010, approach the value of basic chemicals, and by the year 2020 should easily outstrip annual basic chemical revenues. At that time, speciality chemical revenues will rival those for basic chemicals." (Swift, 1999).

Production of high volume basic chemicals, which is a mature market, will shift toward non-OECD countries. The mature markets of Western Europe, the US and Canada are experiencing a declining trend in major petrochemical production capacity. Within OECD, Japan is a notable

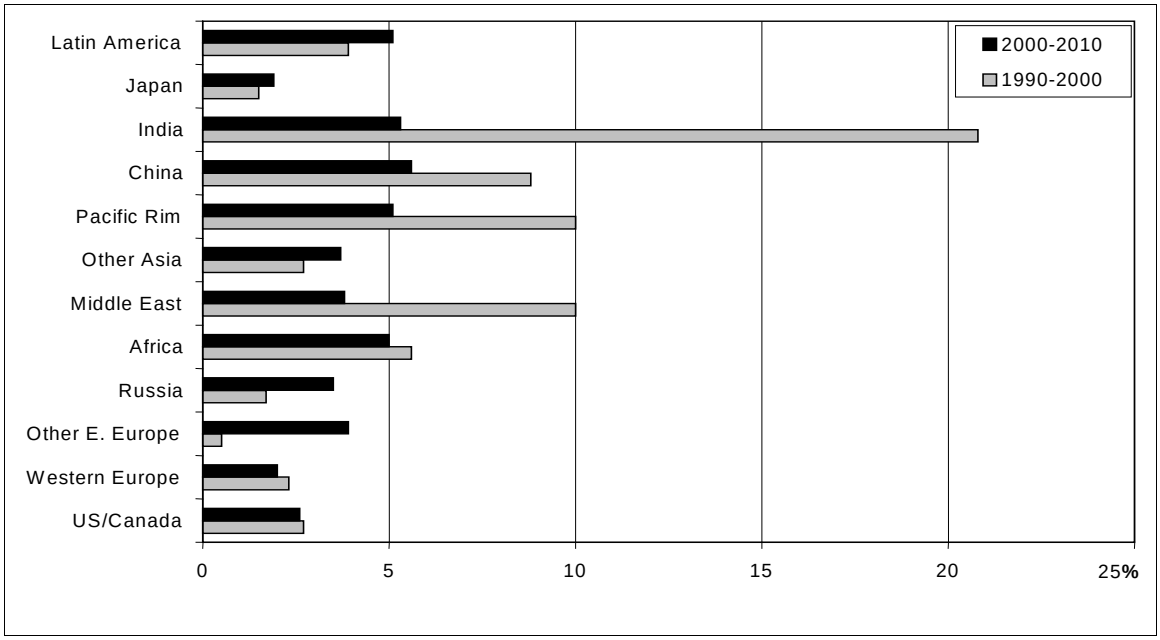
exception in this respect. Figures 11 and 12 show less growth in capacity for 2000-2010 than was seen in 1990-2000 for petrochemicals and plastics (both basic chemicals), particularly in those countries/regions that demonstrated high growth rates in capacity in 1990-2000, such as Africa, the Middle East, China, India and the Pacific Rim; however, growth rates for these products in these countries will remain higher than in OECD countries, although Japan's rate of growth will increase.

Figure 11
Petrochemicals growth rates in capacity (per year)



Source: European Chemical News, 1999 (See Annex 8).

Figure 12
Plastics growth rates in capacity (per year)



Source: European Chemical News, 1999 (See Annex 8).

Investment trends

In the past, most of the investment in chemical plants has been from one OECD country to another; over the next ten years, the rate of investment from OECD countries to non-OECD countries is expected to increase considerably. In response to a 1998 survey of CMA member companies, the US chemicals industry expects to increase the portion of total plant and equipment investment committed to foreign locations in Latin America, Central and Eastern Europe, China, Asia (except Japan) from 1998 to 2003, while decreasing the investment in locations in Canada, Western Europe and Japan over the same period (CMA, 1998b).

Developments in trade

With respect to the chemicals trade, the Reference Scenario predicts that over the next 20 years total volume will continue to increase and trade balances will vary across OECD regions with slight positive balances in some regions and slight negative balances in other regions (see Annex 9). With the exception of the region of the former Soviet Union and the Middle East, all other non-OECD regions will experience significant negative trade balances. (Note: trade here refers to export from one region to another, and not export from one country within a region to another within that same region.)

Other trends

Other expected changes relate to the composition and structure of the industry. It is anticipated that the increasing scale and growth of the global chemicals industry, together with continuing globalisation, increased openness and competitiveness, are likely to intensify recent trends of companies forming alliances in order to achieve economies of scale. Steadily mounting cost pressures will provide further impetus. R&D, bringing new products to the market, managing the safe production and distribution of chemical products from cradle to grave, and meeting pressures of environmental health and safety regulations entail costs that will escalate. The trend towards fewer and larger multinational producers is expected to continue, with companies becoming increasingly knowledge-based (speciality chemicals and life sciences sectors) rather than asset-based (basic chemicals) (CIA, 1999).

Chemical and Engineering News (May 2000) made the following statements: "The value of mergers and acquisitions among chemical companies world-wide hit a record $38.2 billion in 1999, which topped the previous record in 1998. . . . In order to ensure earnings meet expectations for stability and growth, firms are increasingly deciding that they must jettison the low-margin or cyclical businesses. . . . Another trend that shaped mergers and acquisitions last year was the desire by pharmaceutical and life sciences firms to focus on human health and shed chemical and agricultural operations. . . .Deals that advance global consolidation of industries were also important last year" (McCoy, 2000). In 1998, so many large and medium sized chemical companies were devoured that *Chemical and Engineering News* had to turn its "Top 100" to a "Top 75" list. The agrochemicals sector has gone from 27 major companies in 1983 to 12 major companies in 2000 (Johnen, 2000; Annex 10).

4. ENVIRONMENTAL TRENDS AND OUTLOOK

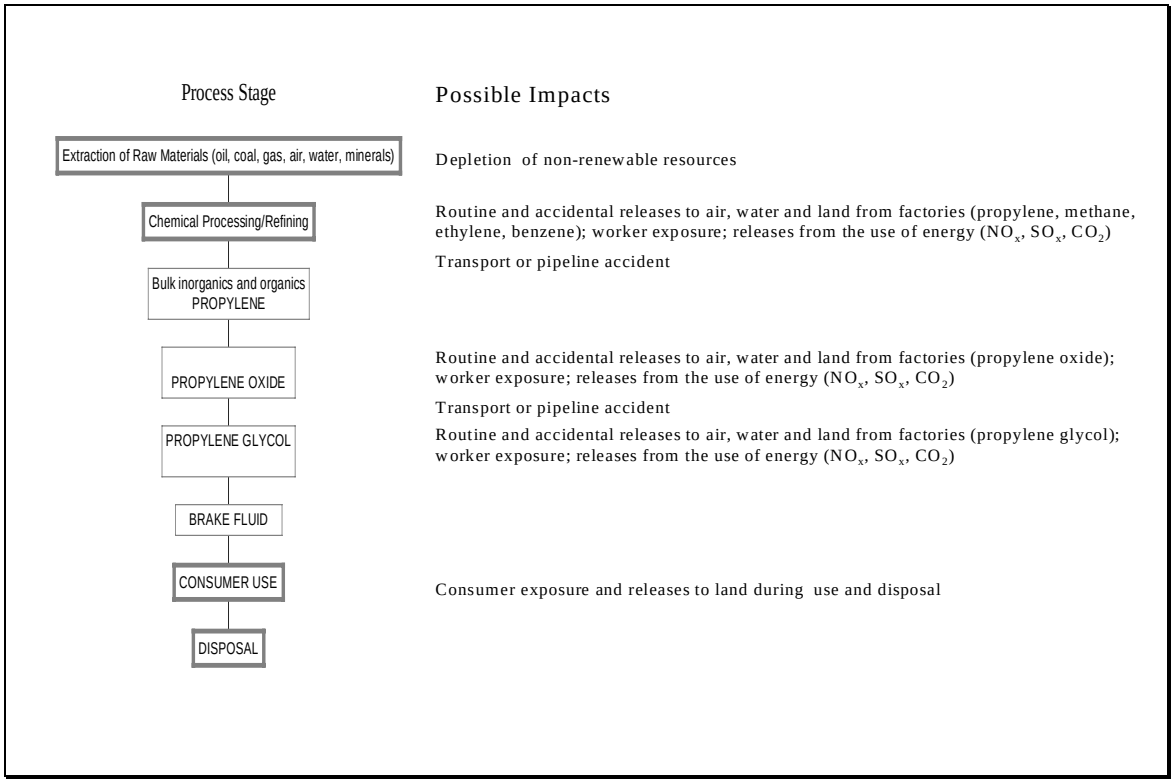
4.1 Effects on the environment of the chemicals industry and its products

While the chemicals industry has brought a number of important products to the market to improve health, provide greater safety, and enhance the quality of life, in doing so it has also released substances into the environment (or its substances have been released during use) that have led to negative impacts on man and the environment (*e.g.* CFCs, PCBs, PBBs). Over the entire life of a chemical product ("cradle to grave"), there is a *potential* for a detrimental impact. In response to government mandates (legislative, regulatory) or on the initiative of industry itself (*e.g.* voluntary reductions, environmental management systems), various techniques have been employed for reducing releases at each of these stages. These include using pollution control equipment (*e.g.* closed or floating roof storage tanks, particle collection systems, thermal incinerators, waste treatment facilities), designing processes to minimise releases, and banning the marketing of a substance or limiting some of its uses. Even so, concerns have been raised regarding chemicals with known effects (*e.g.* endocrine disrupting substances, persistent, bioaccumulative and toxic substances) and their concentrations in the environment, as well as other substances in the environment about which little is known.

Potential impacts

The following describes where in the lifecycle of a chemical product impacts can occur to man and/or the environment, from the extraction of raw materials all the way to the use of the final product and its disposal. These are theoretical impacts for illustrative purposes only, and should *not* be interpreted to mean that significant impacts actually occur at each stage. As an example, Figure 13 portrays potential impacts along the entire chain of production and use of brake fluids.

Figure 13
Potential impacts on health and the environment from the production and use of brake fluid



First, as a major user of raw materials, both for energy consumption (7% of world energy use in 1998) [IEA, 2000a] and as feedstocks, the chemicals industry can significantly impact on the supply of non-renewable resources. And, as these materials are, in general, based on hydrocarbons, combustion of these sources can lead to emissions of carbon dioxide (CO_2) - a greenhouse gas (GHG) – and volatile organic compounds (VOCs) and nitrogen oxides (NO_x) which contribute to the formation of tropospheric ozone or "smog".

Next, the processing of the raw materials and feedstocks can result in the release of hazardous pollutants to the environment (*e.g.* propylene) from emission stacks, discharge pipes, flanges, waste ponds, storage tanks and other equipment. Of all the sectors of the chemicals industry, the basic chemical sector is generally the largest emitter (by volume) of such pollutants because these bulk chemicals are usually produced in high volumes at large plants.

During normal operations, workers can be exposed to pollutants in a gaseous or liquid form, for example by inhaling a pollutant emitted from leaks in equipment or splashing the substance on the skin or in the eyes. Larger accidents involving chemicals can also occur due to equipment failures. Major spills can result in inadvertent releases to workers, the surrounding neighbourhood or perhaps even communities and the environment at some distance from the plant.

At the conclusion of each stage of the process, the product is transported, *via* pipeline, rail, barge/tanker or truck, to the next user for further processing. This can be as close as another part of the same plant, or as far as another company located in another country. Here, too, accidents can

occur leading to exposures of the transport workers and, perhaps, the surrounding community and environment.

The final user of a chemical product can be another chemical company, other industries, or consumers. Depending on the product, and how it is used, there also can be exposures during this end-use phase. For instance, chemicals such as plasticisers and stabilisers found in plastics could leak out during consumer use. Similarly, leakage of brake fluids from automobiles and disposal of these substances (generally classified as hazardous waste) can impact on the environment. The use of some consumer products can have a global impact, as is the case with refrigerants containing CFCs that have led to a depletion of the ozone layer.

Certain chemicals released by the chemicals industry in its production processes can lead to a direct or indirect impact on man and/or the environment. Exposure to certain *hazardous substances* - such as PCBs, DDT, PBBs, heavy metals, endocrine disrupting substances - can lead to a direct toxicological effect on man or the environment from short- or long-term exposure. Other substances - such as VOCs, NOx, SOx - are cause for concern after they react with other substances. For instance, VOCs and NOx promote the formation of smog and SOx is responsible for the formation of acid rain. CFCs are non-flammable and non-toxic, but they react with other substances in the stratosphere to destroy some of the ozone layer and this, in turn, can lead to a greater incidence of skin cancer.

While the chemicals industry is, to some degree, responsible for emissions of greenhouse gases, substances which promote the formation of tropospheric ozone, and CFCs which deplete stratospheric ozone, most attention has been focused on the releases of *hazardous pollutants* as evidenced by this statement from the US EPA: "*While the US chemical industry has been reducing its emissions over time, as of 1994, it was still the biggest emitter of carcinogens released, total pounds released, and quantities transferred each year, compared with all other industries that reported.*" (US EPA, 1997). Further, according to a 1994 World Bank report, the chemicals industry ranked high in its intensity[4] of toxic chemicals released to air and land compared to other large industrial sectors (*e.g.* textiles, automobiles and electronics) (Hettige, 1994). It should be noted, though, that within OECD countries, the chemicals industry has greatly reduced its air emissions and toxic emissions per unit of output in the last two decades (OECD, 2001b). A comparison of pollution intensity for the chemicals industry and other industries is shown in Table 4.

4. "Intensity" refers to the weight of emissions per production output.

Table 4
Pollution intensities of selected manufacturing sectors (kilograms of emissions per US$ 1 million of production output)

	Air						Water		Toxic Chemicals			Bio-accumulative Metals		
	Sulphur Dioxide (SO_2)	**Nitrogen Dioxide (NO_2)**	**Carbon Monoxide (CO)**	**Volatile Organic Compounds (VOCs)**	**Fine Particulates (PM10)**	**Total Suspended Particulates (TP)**	**Biological Oxygen Demand (BOD)**	**Suspended Solids (SS)**	**Air**	**Land**	**Water**	**Air**	**Land**	**Water**
Industrial Chemicals														
- Industrial Chemicals except Fertilisers	2,179	1,779	217	354	0	517	15	201	369	410	0	7	112	0
- Fertilisers and Pesticides	42	443	2	23	0	114	4	94	110	63	0	0	0	0
- Synthetic Resins, Plastics Materials and Manmade Fibres	672	690	64	1,487	0	197	34	79	628	239	0	1	40	0
Iron and Steel	156	253	1,947	66	0	692	0	140	179	660	0	17	489	0
Pulp, Paper and Paperboard	9,625	4,655	2,224	571	0	986	2,911	3,501	467	21	17	0	30	6
Textiles														
- Spinning, Weaving and Finishing	3,394	1,799	169	58	7	239	266	498	160	71	0	15	52	2
Automobile	2	18	3	491	0	5	0	5	211	70	0	2	16	0
Electronics														
- Radio, TV and Communication Equipment	0	34	0	1,016	0	1	0	5	290	238	0	0	111	0
Most Intensive Manufacturing Branch	Cement, Lime and Plaster	Cement, Lime and Plaster	Sawmills, Planing and Other Wood Mills	Distilled Spirits	Oils and Fats	Cement, Lime and Plaster	Pulp, Paper and Paperboard	Pulp, Paper and Paperboard	Ship-building and Repairing	Leather Tanning and Finishing	Pulp, Paper and Paper-board	Non-ferrous Metals	Iron and Steel	Pulp, Paper and Paper-board
	40,012	24,622	2,791	8,200	41	10,377	2,911	3,501	2,400	2,394	17	49	489	6

Note: Figures are Inter-Quartile Mean pollution intensities, an unweighted mean of the plant intensities after dropping those which are below the first quartile or above the third quartile.
Source: World Bank, Industrial Pollution Projection System (Hettige, 1994).

With respect to hazardous chemicals sold as is or used in preparations, complete information does not exist about the volumes released to the environment, the targets of exposure, or the toxic properties of the many substances on the market today. When considering the impact on man and the environment from the annual production of thousands of chemical substances - and the processing and use of countless preparations and articles based on them - information is needed to answer the following questions. One, how many and how much of these substances are released to the environment, and who (man or the environment) is being exposed? Two, what is the hazard posed by these substances - that is, what, if any, are the toxic properties that are inherent in each chemical substance? Once there is adequate information to answer these questions, it will be possible to paint a comprehensive picture of the true risk posed by chemicals. Over the years, government and industry programmes have been initiated to provide some of this data. While complete data are not yet available, it is nevertheless possible to give an indication of the current situation and what it may be in the near future.

The following section examines the current and future trends for environmental impacts due to the use of renewable and non-renewable resources and releases of various types of pollutants during the entire lifecycle of chemical products.

4.2 Trends and outlook for environmental impacts related to production

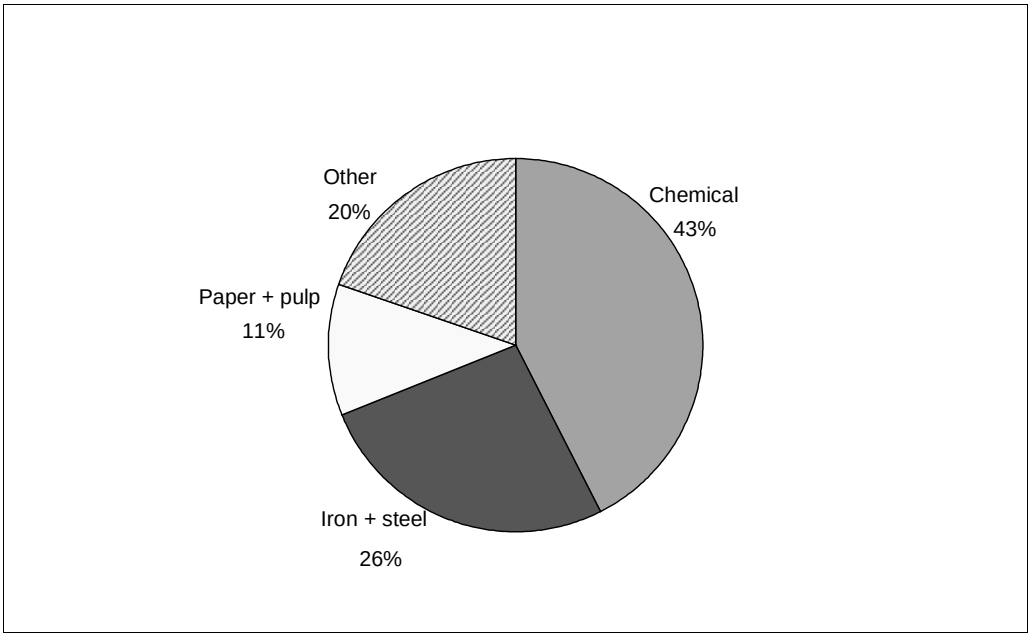
Use of natural resources

The use of raw materials could impact the environment in two ways. First, their use could deplete resources, both renewable and non-renewable; and second, during use, they can create pollution (typically during combustion). The chemicals industry uses a combination of natural gas, coal and coke, minerals, water, fuel oil and liquefied petroleum gas, and electricity as a source of energy and for feedstocks.

Water

Of all the *manufacturing* industries within OECD countries, the chemicals industry was the largest consumer of water in 1995 (see Figure 14). It should be noted, though, that worldwide, agriculture is by far the largest user of water (69%) followed by manufacturing industries (23%) and domestic use (8%) (OECD, 2001a).

Figure 14
Industrial water use in OECD countries (1995)



Source: Polestar[5] (See Annex 11).

In the chemicals industry, water is primarily used as a feedstock, for waste control, and for cooling thermal electric power plants and other heat sources. The numbers above do not, in and of themselves, indicate a problem, but governments are instituting general policies to encourage water conservation and increased water efficiency. Data concerning water use over time by the chemicals industry are not currently available.

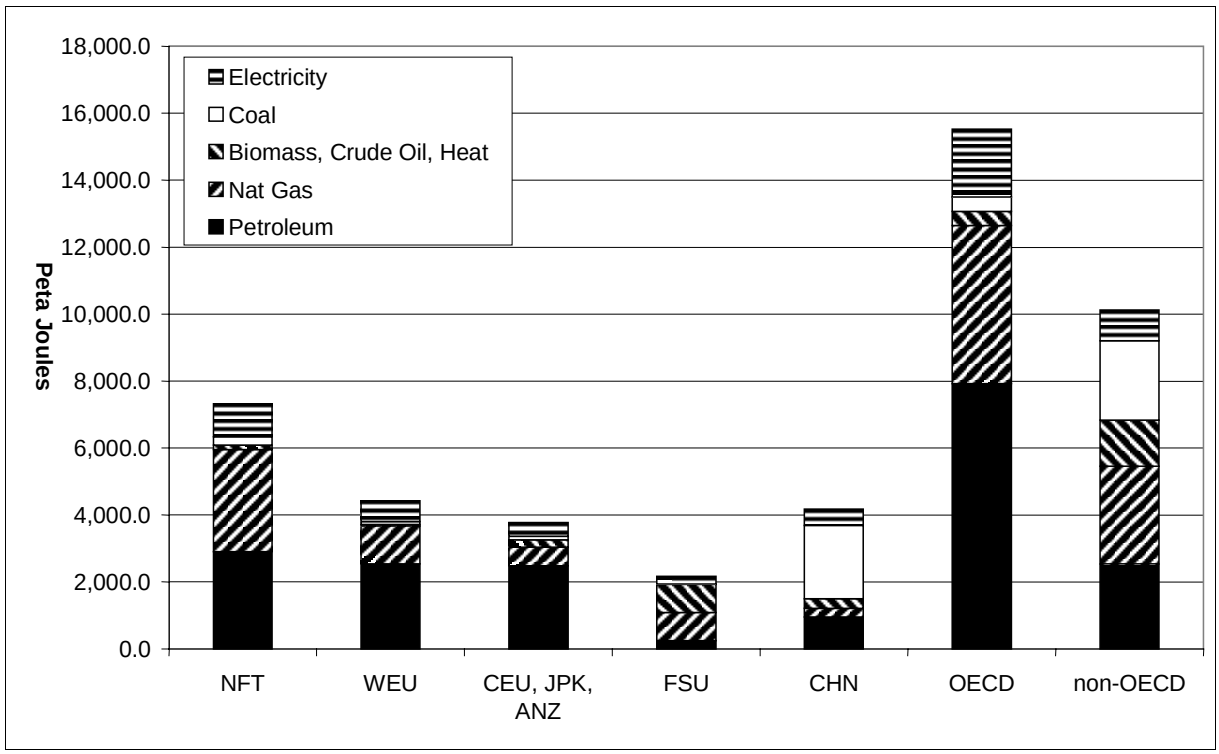
It should be noted that the impact of water use on the environment is not solely due to the *volume* of water consumed, but also to the *form* in which it is returned to the environment. Obviously, the discharge of polluted water is a concern, but the discharge of heated effluent can also have a significant impact on aquatic ecosystems.

Oil, natural gas and coal

Figure 15 shows energy consumption by source for the chemicals industry in OECD and non-OECD regions in 1995. OECD countries are a much smaller user of coal (which produces more CO_2 per unit of energy) than non-OECD countries, especially compared to China.

5. Polestar, developed by Stockholm Environment Institute-Boston, is a software tool to aid in the generation and evaluation of alternative development scenarios. The Polestar data provided in this report were generated by Polestar using OECD Reference Scenario model data (economic and demographic assumptions) as input.

Figure 15
1995 Chemicals industry process fuel use for energy (by region[6])



Source: Polestar (See Annex 12).

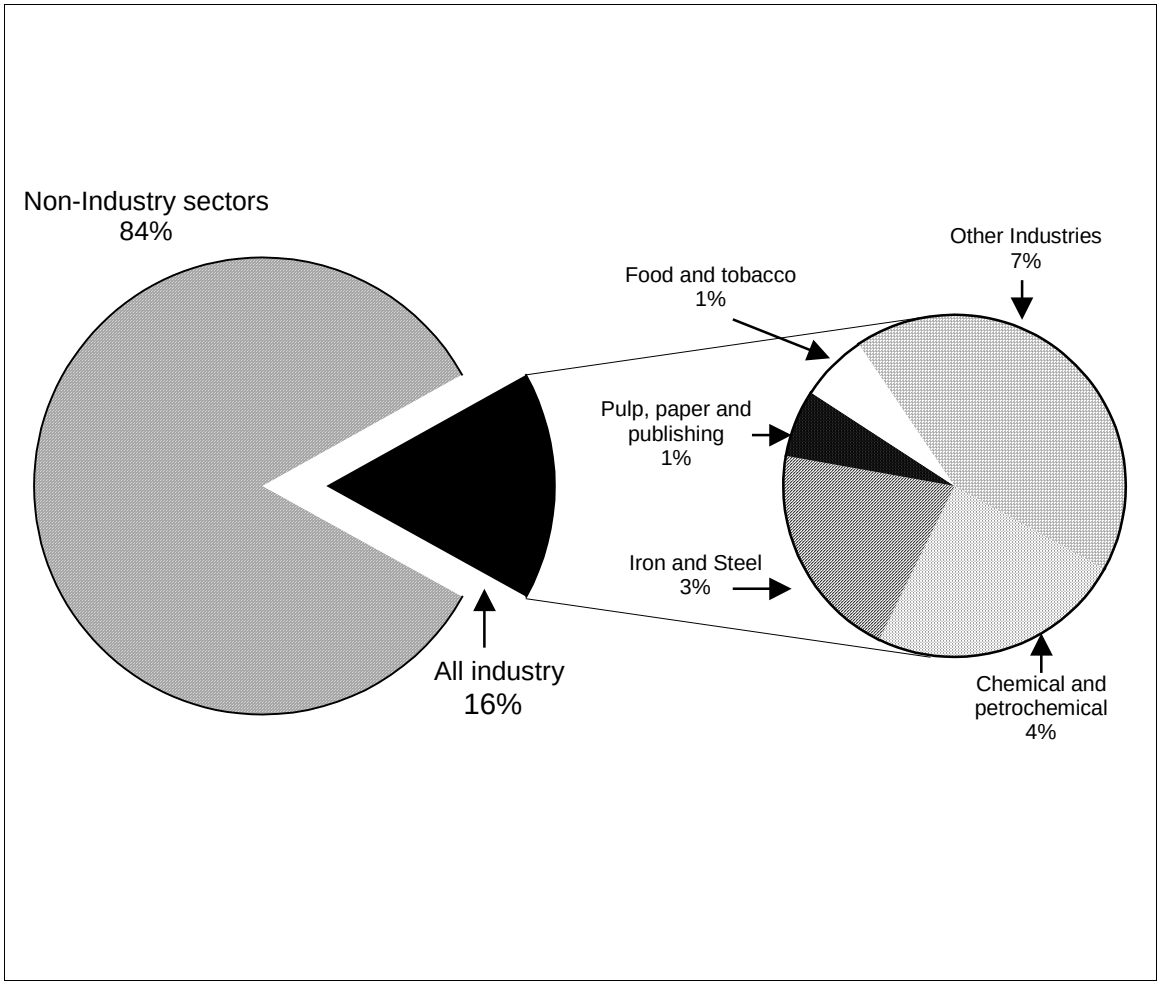
Releases to air and water, and waste generation

Energy use and CO_2 emissions

The chemicals industry is energy intensive and accounted for some 7% of total world energy use in 1998 (IEA, 2000a). It relies on energy inputs as fuel for power and as raw materials in the manufacture of many of its products. The chemicals industry contributes only 4% of overall emissions of CO_2 from all sectors using fossil fuel combustion (see Figure 16); however, when compared to other industries (*e.g.* pulp and paper contributes just 1%), the chemicals industry in OECD countries is nonetheless a major *industrial* emitter.

6. NFT-NAFTA (US, Canada, Mexico); WEU-Western Europe; CEU-Central and Eastern Europe; JPK-Japan and Korea; ANZ-Australia and New Zealand; FSU-Former Soviet Union; CHN-China

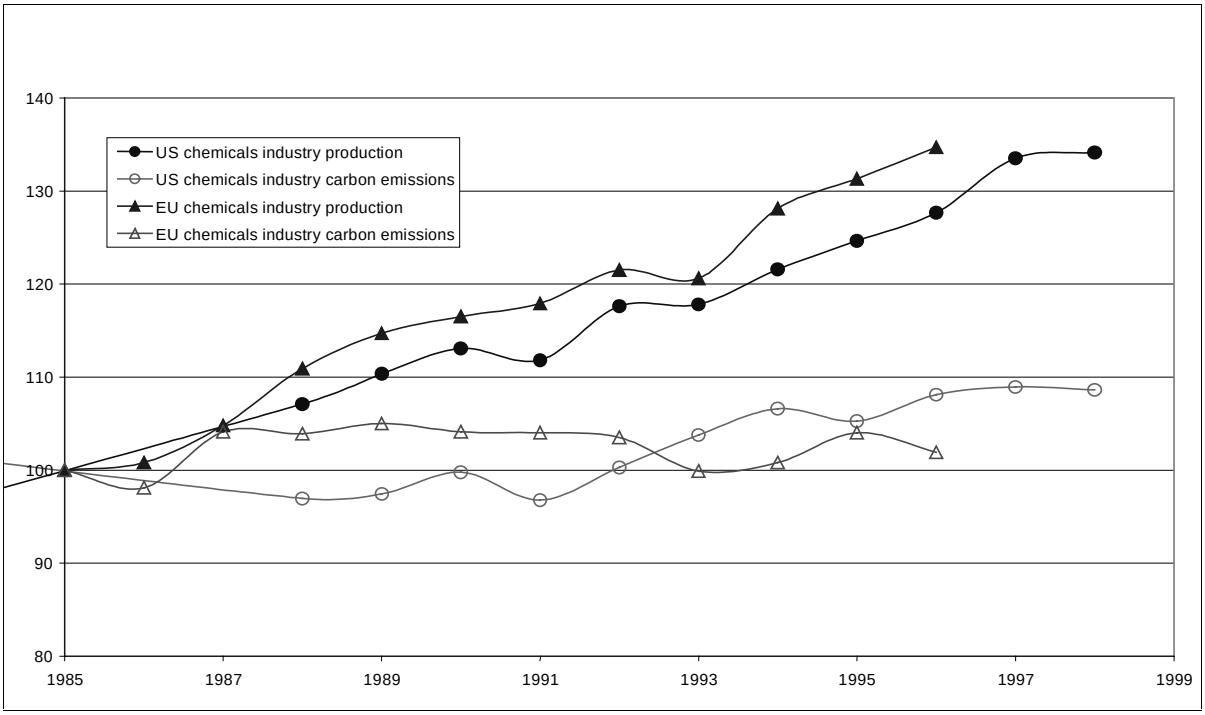
Figure 16
1997 CO_2 emissions from fuel combustion in OECD countries



Source: IEA (1999b)
Note: The "chemical and petrochemical" category shows CO_2 emissions from both the chemicals manufacturing industry and the petrochemical industry.

Global trend data on total CO_2 emissions from the chemicals industry are not readily available, but data reported by the European and US chemicals industries indicate that CO_2 emissions have stabilised while production has been increasing (Figure 17). In the EU, CO_2 emissions increased 2% between 1985 and 1996. However, in this same period production grew 34% and energy consumption levelled off, demonstrating significant energy efficiency gains (CEFIC, 1998). In the US, CO_2 emissions increased by 3.3% between 1980 and 1998, but energy consumption per unit of production declined by 43% between 1974 and 1998 (CMA, 1999a).

Figure 17
Indexed US and EU chemicals industry production and CO_2 emissions



Source: CMA (1999a); CEFIC (1998)

In Japan, CO_2 emissions increased slightly between 1990 and 1998, but there was approximately a 70% reduction in unit energy consumption between 1970 and 1998 (JRCC, 1999); the biggest reduction was between 1970 and 1980, with unit energy consumption remaining fairly constant since the mid 1980s despite large increases in production. Improvements in unit energy consumption by the Japanese chemicals industry have been better than those made by the pulp and paper, ceramics and cement, iron and steel and other manufacturing industries. It should be noted that energy efficiency is subject to decreasing returns - the higher the level of efficiency attained, the harder it becomes to improve it further.

There are two trends which, taken *together*, could be cause for concern. One, the share of world energy use by the chemicals industry in non-OECD regions is growing. Their share has increased from 19.8% in 1971 to 42.9% in 1998 (see Table 5). No energy efficiency data are readily available for the chemicals industry in non-OECD countries. Two, when combined with the fact that in non-OECD countries, the rapidly expanding chemicals industry has increased its reliance on coal, particularly in China (see Table 6), there could be cause for concern. Coal produces more CO_2 on a per unit energy basis than oil or gas (IPCC, 1996). In OECD countries, on the other hand, there has been a reduction in the use of coal as an energy source by the chemicals industry and an increase in the use of oil which has helped stabilise CO_2 emissions.

Table 5
World energy use in the chemicals industry for 1971 and 1998 (in %)

Region	1971	Region	1998
OECD America	37.2	OECD America	27.0
OECD Europe	30.0	OECD Europe	18.9
Non-OECD f. USSR	14.9	Non-OECD China	15.3
OECD Pacific (incl. Japan and Korea)	13.0	OECD Asia (Japan)	11.3
Non-OECD Asia (excl. China)	1.7	Non-OECD Asia (excluding China)	8.4
Non-OECD Europe	1.6	Non-OECD f. USSR	6.5
Non-OECD Latin America	0.8	Non-OECD Middle East	5.3
Non-OECD Middle East	0.7	Non-OECD Latin America	4.0
Non-OECD Africa	0.2	Non-OECD Africa	2.0
Non-OECD China	0.0	Non-OECD Europe	1.3
Total % share OECD countries	80.2	Total % share OECD countries	57.1
Total % share non-OECD countries	19.8	Total % share non-OECD countries	42.9

Source: IEA (2000a).

Table 6
Shift in the type of sources used for energy by the chemicals industry between 1971 and 1998 for OECD and non-OECD countries

	% Share in Energy Use			
	OECD		Non-OECD	
	1971	1998	1971	1998
Oil	51	58	21	31
Coal	9	2	7	21
Gas	27	26	31	32
Electricity	11	13	13	9
Heat	1	1	27	7

Source: IEA (2000a)

The data on CO_2 emissions from the chemicals industry reported above are for manufacturing only. They therefore take no account of contributions to CO_2 emissions and other GHG emissions from the chemicals industry's products. If a full picture of the industry's contribution to GHG, spanning the complete lifecycle of its products, were required, these "downstream" emissions should be added to the reported manufacturing emissions. In addition, the discussion of the contributions of the chemicals industry to climate change is restricted to CO_2 emissions since data on emissions of other GHGs are not readily available.

All OECD countries have energy efficiency programmes in place to achieve savings in energy use. Government programmes have raised the profile of energy efficiency in all sectors of the economy, and the overall energy efficiency of OECD economies has improved. Estimates of efficiency savings that can be achieved at zero or negative costs often range as high as 30% of total energy use. The extent to which these changes are due to government intervention or to market forces is unclear, although voluntary industry initiatives have been, and will continue to be, important. (A number of examples of voluntary energy reduction programmes are illustrated in Annex 13.)

Since the demand for chemicals is projected to increase to 2020 (according to the OECD Reference Scenario), energy use by the chemicals industry will also increase as there is probably limited potential for further major efficiency improvements, particularly for companies based in OECD countries. The OECD Reference Scenario projects that CO_2 emissions from the chemicals industry in OECD countries will increase by 66% from 1995 to 2020 (following total industry trends in OECD countries), while the increase in non-OECD countries will be 165% during the same period (following total industry trends in non-OECD countries) (see Annex 14). However, if greater energy efficiency gains are achieved in the chemicals industry, CO_2 emissions may increase at slower rates or remain stabile in OECD countries. In the future, the chemicals industry in OECD countries is expected to produce less CO_2 emissions than the chemicals industry in non-OECD countries; in fact, by 2020 it is estimated that China's chemicals industry alone will produces almost as much CO_2 as the entire chemicals industry in OECD countries put together (see Annex 14).

Future trends in CO_2 emissions, while obviously related to energy use, will also depend very much on the commitments made by government and industry to fulfil goals set in the Kyoto protocol. The costs of such reductions will vary depending on the strategy that is chosen (*i.e.* voluntary or mandatory instruments, use of emissions trading).

Substances that promote the formation of tropospheric ozone and acid rain

Little global data are available on the total contribution by the chemicals industry to the release of substances which promote the formation of tropospheric ozone (*i.e.* VOCs, NOx) and acid rain (SOx). However, data from the US show that the chemicals industry is a relatively small contributor to total US emissions of these pollutants, and releases of these substances have generally been declining (see Table 7).

Table 7
Key pollution indicators for the US for 1985, 1990 and 1995 (in 1000 US short tonnes)[7]

		1985	1990	1995
Nitrogen Oxides	Total emissions	23,488	23,792	23,935
	Chemicals industry - % of Total	1.1	0.7	0.7
Volatile Organic Compounds	Total emissions	24,227	20,985	20,586
	Chemicals industry - % of Total	*3.6*	*3.0*	*3.2*
Carbon Monoxide	Total emissions	115,644	96,535	89,721
	Chemicals industry - % of Total	*1.6*	*1.2*	*1.4*
Particulates	Total emissions	45,584	29,947	26,888
	Chemicals industry - % of Total	*0.1*	*0.3*	*0.2*
Sulphur Oxides	Total emissions	23,230	23,136	18,552
	Chemicals industry - % of Total	*2.0*	*1.3*	*1.5*

Source: US EPA as presented in CMA (1998a)

Similar declining or stable trends for emissions from the chemicals industry have been observed in a number of other OECD countries. For instance, in Japan, SOx emissions fell during the 1980s, but have since increased slightly, and NOx emissions increased marginally between 1990 and 1998, although unit emissions have remained stable (JRCC, 1999). Since first reporting in 1995, total

7. 1 US short tonne = 0.90703 metric tonne.

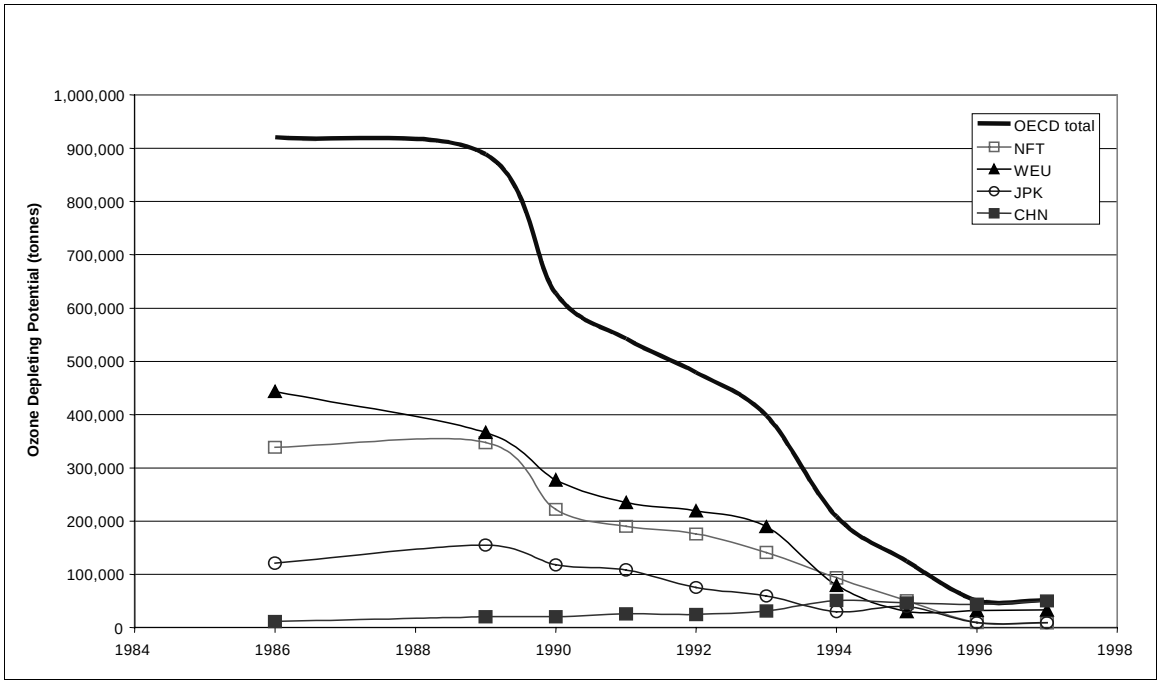
VOC emissions from the UK chemicals industry have fallen by 46% (CIA, 2000). In the Belgian regions of Flanders and Wallonia emissions of SOx and VOC also fell significantly from 1987 to 1995, with decreases ranging between 71-81% and 48-64% respectively (OECD, 1998b). In Switzerland, over the last 20 years, SO2 emissions have fallen 75%, NOx emissions by 30% and non-methane VOC emissions by 45% (Buwal, 1995).

Likewise, in the Slovak Republic, the Association of the Chemical and Pharmaceutical Industry - which represents over 90% of the industry's total turnover - reported that its members had from 1992 to 1999 significantly reduced SO_2, NOx and VOCs emissions (41.3% for NOx, 15.3% for SO_2 and 44.7% for VOCs) (Responsible Care, 2000). And from 1989 to 1999, members of the Italian Chemical Industry Association (ICIA), which agreed to the Responsible Care Programme and represent 60% of the Italian chemicals industry, also significantly reduced emissions of SO_2, NOx and VOCs by 76.7%, 63.9% and 81.8%, respectively (ICIA, 1999).

Ozone depleting substances (ODS)

Global atmospheric concentrations of ODS show important changes. Over the last 15 years, tremendous progress has been made in phasing out the production and consumption of chemicals that deplete the ozone layer. The rapid progress in phasing out *production* of CFCs is illustrated in Figure 18. However, while growth rates of CFC concentrations have decreased substantially since 1989, and production of most other ozone depleting substances show a similar trend, growth rates of hydrochloro- fluorocarbons (HCFCs) are rising, reflecting increasing production. Although HCFCs have only 2-5% of the ozone depleting potential of CFCs, they are likely to remain in the stratosphere for a long time since, under current agreements, they will not be phased out for at least 20 years. It should also be noted that interim substitutes for CFCs, such as HCFCs and HBFCs, have a very high global warming potential.

Figure 18
Production of CFCs for selected countries and regions



Source: UNEP, 1999 (see Annex 15)

It is expected that the production and consumption of ODS will be phased out according to the agreed schedules of the Montreal Protocol. Nevertheless, substances that cause stratospheric ozone depletion will remain a source of some concern due to the long time lag between their release and their arrival in the stratosphere.

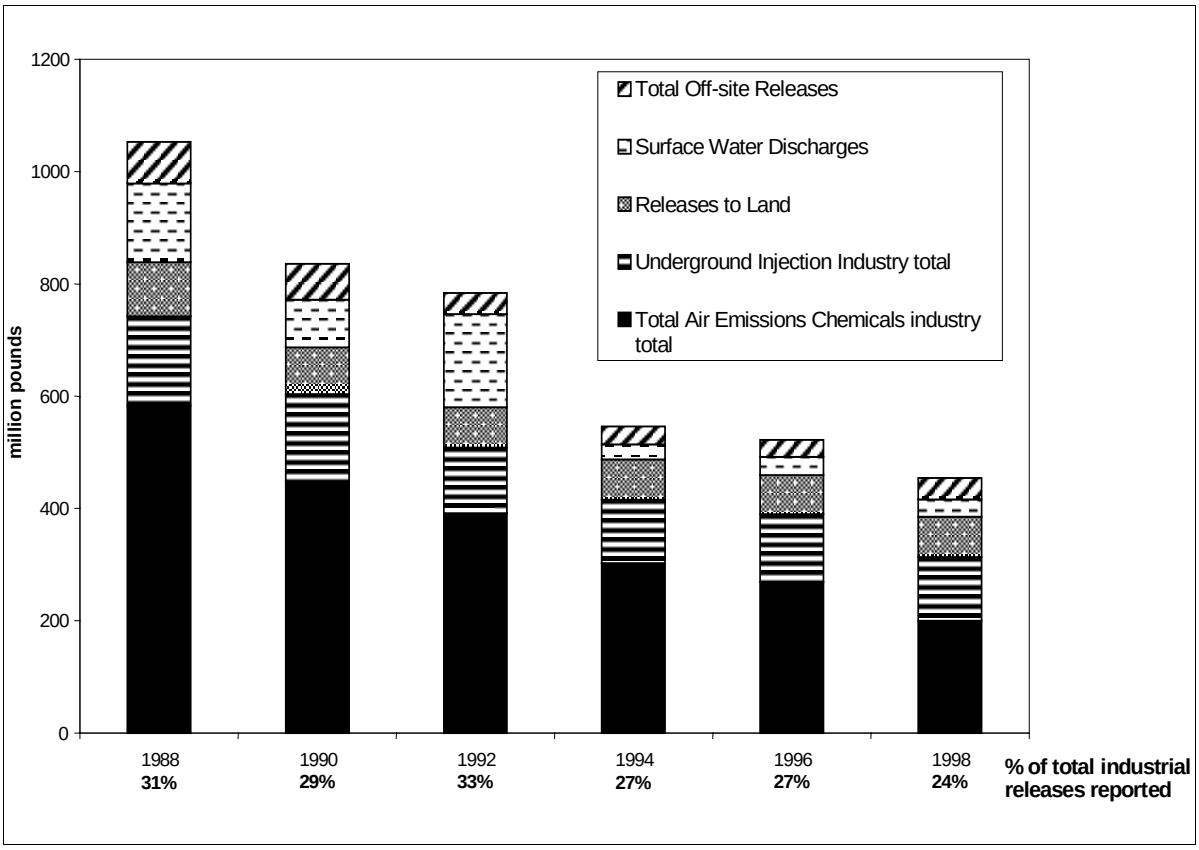
Hazardous substances

Unlike climate change substances which have, for the most part, been identified, the number and volume of hazardous substances released during chemical production processes remain unknown. There is no one universal list of such substances. Different countries establish their own lists of substances they consider to be hazardous based on data available to them. Thus, substances which may be hazardous, but which have not yet been characterised as such due to a lack of toxicity data, are not listed. Further, two countries, although using the same data, may not characterise the hazard the same way.

With respect to releases of hazardous substances (as they are defined by specific governments) to the environment from chemical plants, consolidated data also do not exist. Even though all countries collect some data on emissions of hazardous substances to the environment (*e.g.* through reporting for permits, or Pollutant Release and Transfer Registers), they do not necessarily collect data on the same chemicals (see Annex 16 for a list of countries which have PRTR systems in place, or will shortly). Information on releases of hazardous substances for the US, Canada, Italy, Japan and the UK is provided below and illustrates that, in general, these emissions and releases are decreasing. Similar trends are probably occurring in other OECD countries where regulations and other policy instruments have been in place for some time, but the situation for the chemicals industry in non-OECD countries is unclear - or even unknown.

Between 1988 and 1998, releases by the US chemicals industry of the hazardous chemicals ("core chemicals") listed on the 1988 Toxic Release Inventory (TRI) showed a continuous decrease (see Figure 19). ("Core chemicals" are those chemicals that were on the TRI list in both 1988 and 1998 and do not include substances added or deleted in the interim.) The inorganic chemicals sector in the US reported the greatest volume of releases (27%), followed by the organic chemicals (25%), and agricultural chemicals (21%) sectors.

Figure 19
Releases of core chemicals by the US chemicals industry (1988-1998)



Source: US EPA, 2000a (see Annex 17)
Note: The 1998 figure for % of total industrial releases does not consider the seven industries added to the US TRI Program in 1998

Reductions of the core chemical releases to air and surface water account for the bulk of the improvements from 1988 to 1998. Chemicals industry releases also decreased relative to total releases reported from all manufacturing industries (US Standard Industrial Classification Codes 20-39). Between 1995 and 1998, a similar pattern is seen for releases of core chemicals listed in the 1995 TRI. With the 1998 inclusion of seven additional industries to the TRI reporting programme (metal mining, coal mining, electric utilities, chemicals distributors, petroleum bulk terminals, hazardous waste treatment and disposal facilities, and solvent recovery services), the chemicals industry now only contributes 10% of total industry emissions (as reported to the TRI) compared to 31% in 1988 (US EPA, 2000a). These improvements have been achieved over a period (1988-1998) when US chemicals industry production rose by over 35% (CMA, 1999a).

In Japan, chemicals industry emissions of 12 priority air pollutants[8] have decreased by 35% between 1995 and 1998. Emissions of acetaldehyde, trichloroethylene, and formaldehyde fell by more than 50%. Chemical Oxygen Demand (COD) emissions loads fell dramatically between 1970 and 1978 and have remained at low levels (JRCC, 1999).

In the UK, chemicals industry emissions[9] of "Red List" substances were 96% lower in 1998 than in 1990. These are 27 substances (including mercury and its compounds, and carbon tetrachloride) which are particularly hazardous when discharged to water bodies or sewers (CIA, 2000).

Canadian Chemical Producer's Association[10] (CCPA) members reported that their emissions of 15 substances on Canada's Priority Substance List decreased by 37% from 1997 to 1998, and by 73% since 1992. Under the Canadian Accelerated Reduction/Elimination of Toxics[11] (ARET) Programme, CCPA members have reduced emissions by 57% since 1992 (Caswell, 2000).

According to the Italian Chemical Industry Association, COD loads from the chemicals industry agreeing to the Responsible Care Programme decreased by approximately 45% from 1989 to 1999 to 27,275 tonnes in 1999, nitrogen releases decreased from 5,730 to 2,310 tonnes, and heavy metals releases decreased from 58 to 23 tonnes (ICIA, 1999).

Waste

The chemicals industry contributes to the generation of total industrial or manufacturing waste in several ways. First, hazardous substances generated during manufacturing may be disposed of on land (either at a manufacturing facility or shipped to another facility off-site) or incinerated, or treated by physical/chemical means. Materials can also be recovered from this waste and it can be used as a source of energy. Hazardous chemicals produced by the chemicals industry and incorporated into products which work their way through the supply chain will eventually be disposed of after final use (*e.g.* brake fluids). In addition, the chemicals industry produces non-hazardous waste.

Most data on hazardous waste generated by the chemicals industry refer to the volume of hazardous chemicals contained *in the waste* (as with the TRI data above), and not the volume of total waste. For instance, if a barrel contained 10 pounds of a hazardous pollutants and 40 pounds of non-hazardous pollutants, the entire barrel (all 50 pounds) would be considered hazardous waste, but only 10 pounds would be reported to the US TRI.

The OECD only has information from three countries that distinguish total hazardous waste generation by industrial sectors (*e.g.* the chemicals industry). In Finland, of the total hazardous waste generated by all of industry in 1992 (559,000 tonnes), 46% is attributed to the oil and chemicals industry (TILASTOUUTISIA, 2000). In Ireland, of the 167,406 tonnes of hazardous waste generated by industry in 1995, waste from organic chemical processes amounted to 140,793 tonnes, or 84% of

8. dichloromethane, acrylonitrile, vinyl chloride monomer, 1,2-dichloroethane, 1,3-butadiene, benzene, acetaldehyde, tetrachloroethylene, formaldehyde, chloroform, trichloroethylene and ethylene oxide

9. Note, the data quoted are from companies that are members of the Chemical Industries Association in the UK.

10. Note, CCPA membership does not include all chemical companies in Canada.

11. ARET definitions of "toxic" are based on the intrinsic properties of the substances, not on risk (see Annex 19 for further details).

the total. The organic chemicals industry also generated 67,958 tonnes of non-hazardous waste, or 0.16% of the 4,243,900 tonnes generated in 1995 (Ireland Environmental Protection Agency, 1996). In Italy, of the total amount of hazardous waste generated by all industries in 1997 (2,218,150 tonnes), the chemicals industry accounted for 29.5% (IAEP, 1999). According to the ICIA, total waste (hazardous and non-hazardous) generated by the chemicals industry decreased by 57% from 1989 to 1999.

In Japan, the volume of waste (hazardous and non-hazardous) produced by the chemicals industry has increased slightly between 1996 and 1998. However, approximately 71% of waste is disposed of by on-site recycling and volume reduction, and the volume of final off-site disposals has been reduced from around 15% in the early 1990s to 9% in 1998. Most companies have established waste reduction targets (JRCC, 1999).

It is even more difficult to determine the amount of all domestic waste attributable to products manufactured by the chemicals industry.

In general, it is expected that emissions of hazardous chemicals and air pollutants, as well as the generation of waste, from the chemicals industry will continue to decrease in OECD countries. Data on these releases should also improve significantly in the next few years as Pollutant Release and Transfer Registers are established in OECD countries (see Annex 16). How the situation on releases will evolve in non-OECD countries is unclear since no past trends data are available. However, as chemical production increases in these countries, so may environmental releases and waste.

Releases due to chemical accidents

Accidents involving hazardous substances happen every day. Fortunately, the vast majority of them are only "incidents" given the low quantity of chemicals released or the limited consequences of the events. Major accidents are relatively rare. This makes it difficult to determine meaningful trends in their occurrence. In addition, two different factors need to be considered when looking at statistics on major industrial accidents: over the last two decades, overall industrial activities have grown substantially while both governments and industry have worked towards increased safety. Since the early 1980s, the public and private sectors have invested a great deal in prevention and preparedness measures. Governments have developed regulations and put enforcement programmes in place, and chemical companies have taken measures to prevent pollution and accidents, and initiated voluntary programmes to improve safety (*e.g.* Responsible Care). However, it is difficult to say how these measures have influenced safety and whether they have actually contributed to a reduction in the number of chemical accidents. Finally, in the OECD countries, requirements for accident reporting have, in general, been introduced fairly recently and data-collecting methodologies are not necessarily comparable.

In the US, all releases of hazardous substances (as defined under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 - CERCLA) have to be reported to the Emergency Response Notification System (ERNS) database. For the period 1987-1994, the number of releases has increased (see Table 8).

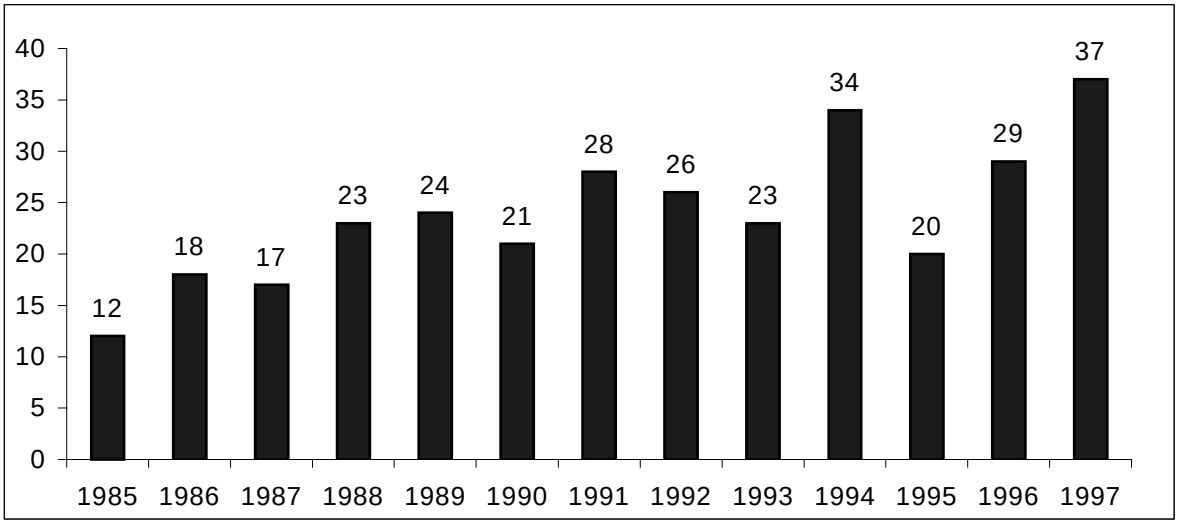
Table 8
Notifications of CERCLA chemicals releases in the US (1987-1994)

1987	1988	1989	1990	1991	1992	1993	1994
4,541	5,176	6,865	6,555	6,801	7,181	7,201	7,656

Source: US EPA (2000c)

In the EU, more than 300 major chemical related accidents (as defined in the "Seveso" Directive) have been reported to the EC Major Accident Reporting System (MARS) between 1985 and 1997. Since 1985, the yearly number has steadily increased (see Figure 20) (European Commission, 2000).

Figure 20
Number of major chemical release accidents in the EU reported to the MARS Database, 1985-1997



Source: European Commission (2000)

As far as the consequences of such accidents are concerned, the focus has been mainly on human health effects, and little is known about the impacts on the environment. In the EU, chemical accidents that cause ecological harm often involve water pollution (and this pollution is frequently the result of firewater runoff).

Data collected within the EU (MARS) show that, on average, over the period 1985 to 1997, 16% of all major chemical accidents resulted in a fatality, and one-third of the fatalities were among members of the surrounding community. European chemicals industry data (which also include some non-EU countries) show that, on average, there are 50 fatalities at chemical plants each year (CEFIC, 2000). For non-fatalities (*i.e.* injury and illness), data collected in the US show that these have decreased from 3.6 cases per 100 full-time employees of member companies of the US Chemical Manufacturers Association in 1990 to 1.9 cases per 100 full-time employees in 1998 (CMA, 1999a).

The economic consequences of major chemical accidents are often severe for the companies concerned (*e.g.* bearing the costs of property damage and emergency services, loss of production and loss of image as well as of clean-up operations and legal fees). However, in OECD countries, the

overall costs of chemical accidents do not seem to be very high: rough estimates range from US$5-10 per year and inhabitant (OECD, 2000b).

4.3 Trends and outlook for environmental impacts related to products

The final use of chemical products can result in the release of hazardous substances affecting man and the environment. They can be released to the indoor environment in the form of chemicals such as formaldehyde from wood panels, plasticisers and stabilisers from plastics, para-dichlorobenzene from mothballs and tetrachloroethylene from dry-cleaned clothes. They can be released to the atmosphere following the use of a solvent, to water from the runoff of pesticides, or to soil - and then, possibly, to the groundwater below - from the final disposal of a product. With the exception of pesticides, data are extremely limited on how many chemical products there are on the market today, on their chemical content, and on whether - and how - they may be releasing hazardous substances to the environment.

Some monitoring data are available for certain substances in the environment; however, in general, only surrogates for data on the rate (and volume) of releases from products exist. For instance, for pesticides there may be a fair amount of data on pesticide use as measured by volume of active ingredient, but measurement of volume consumed does not necessarily reflect environmental impact as the concentrations and toxicity of the active ingredients can change over time.

Substantial data have been collected on pesticide use, or consumption, in OECD countries. The OECD publishes environmental data compendia every two years - the latest was in 1999 - which describe trends in the use of different categories of pesticides (herbicides, insecticides, fungicides). These compendia are based on data provided by the Food and Agriculture Organization (FAO) (which collects them through a written survey), and are reviewed by OECD governments (see Annexes 18a and 18b). In 1999, the European Environment Agency published statistics on pesticide consumption in *Environment in the European Union at the Turn of the Century* (EEA, 1999) and a number of individual countries also publish trends in pesticide use.

Existing data on pesticide use throughout OECD countries are far from perfect, however, and can be very inconsistent (good data for some countries, practically no data for others). In many cases the data are a combination of data on actual pesticide use (*e.g.* collected through interviews with farmers) and data on pesticide sales, which are a less than perfect surrogate for actual use: a given pesticide may be used on many different crops, or stored for use the following year, so sales data can provide only rough estimates of how and when the pesticide was actually used. To date, only the UK and the state of California have complete and reliable data on pesticide use, collected from farmers on a consistent basis over the past 10-30 years. Many OECD governments have only sales statistics, if that, and some collect sales statistics and representative samples of actual use data.

The broad statistics published by the OECD and EEA pose an additional problem. They group pesticides into categories so large that they give little information about environmental impact. For example, the category “insecticides” includes a multitude of chemicals with highly varying degrees of toxicity, persistence, and leachability. A trend in overall insecticide consumption (measured by volume applied) may go down over a period of five years, but if the individual insecticides used have become more toxic, then risk will probably rise during those five years. The OECD Pesticide Programme is developing pesticide risk indicators, which should give a more useful indication of the progress with pesticide risk reduction.

Many OECD governments are leery of pesticide use statistics because they can so easily give a false impression. Nevertheless, pesticide use data are essential for tracking risk trends (which involves combining use data with data on hazard and exposure). As a result, OECD governments have in recent years become keenly interested in obtaining better data on pesticide use, and efforts have been initiated to get such data.

The first efforts were undertaken by several Scandinavian countries and the Netherlands, which needed data to measure their progress in meeting new pesticide use-reduction and risk-reduction goals. More recently, Eurostat (the EU statistical body), has launched two projects to improve data collection on pesticide use in Europe. The first, the TAPAS project (Technical Action Plan for Agricultural Statistics) is helping EU countries (both technically and through funding) to develop programmes for collecting pesticide use data. The second involves an agreement with the European Crop Protection Association (ECPA), which will collect information from its member companies (accounting for the bulk of pesticide sales in Europe) on the use of individual pesticides in EU member states and Norway. The initial project will cover the years 1992-1996 and the major crops responsible for most pesticide use, and will include only fungicides, herbicides and insecticides. The US is also collecting more use data (from states other than California), and Canada is beginning to collect sales data.

For products that are not pesticides, some OECD countries have established product registers to track how a chemical product or preparation will be used, in what volumes, and the concentration of its components as it works its way through the supply chain. Denmark has registered information on an estimated 77,000 products which represent 50 to 60% of all chemicals on the market in Denmark**,** but this can vary from 10 to 90% for different branches of industry and types of product (Kraft, 1999). With this information, it is possible to make a quantitative estimation of emissions of substances. However, it is difficult to get a clear sense of their actual downstream use since not every processor in the lifecycle of a product reports data for such registers, and they do not include information on chemicals contained in imported articles.

The US state of New Jersey requires around 700 facilities that manufacture or process chemicals in New Jersey and that use, or generate, the largest quantities of hazardous substances, to develop Pollution Prevention Plans which document the use and generation of these substances. A 1996 report (Aucott *et al*., 1996) indicated that use of chemicals at these facilities had declined since 1990. But, as with pesticides, it is not always possible to correlate a reduction in use with a reduction in risk.

4.4 Pollution control expenditures

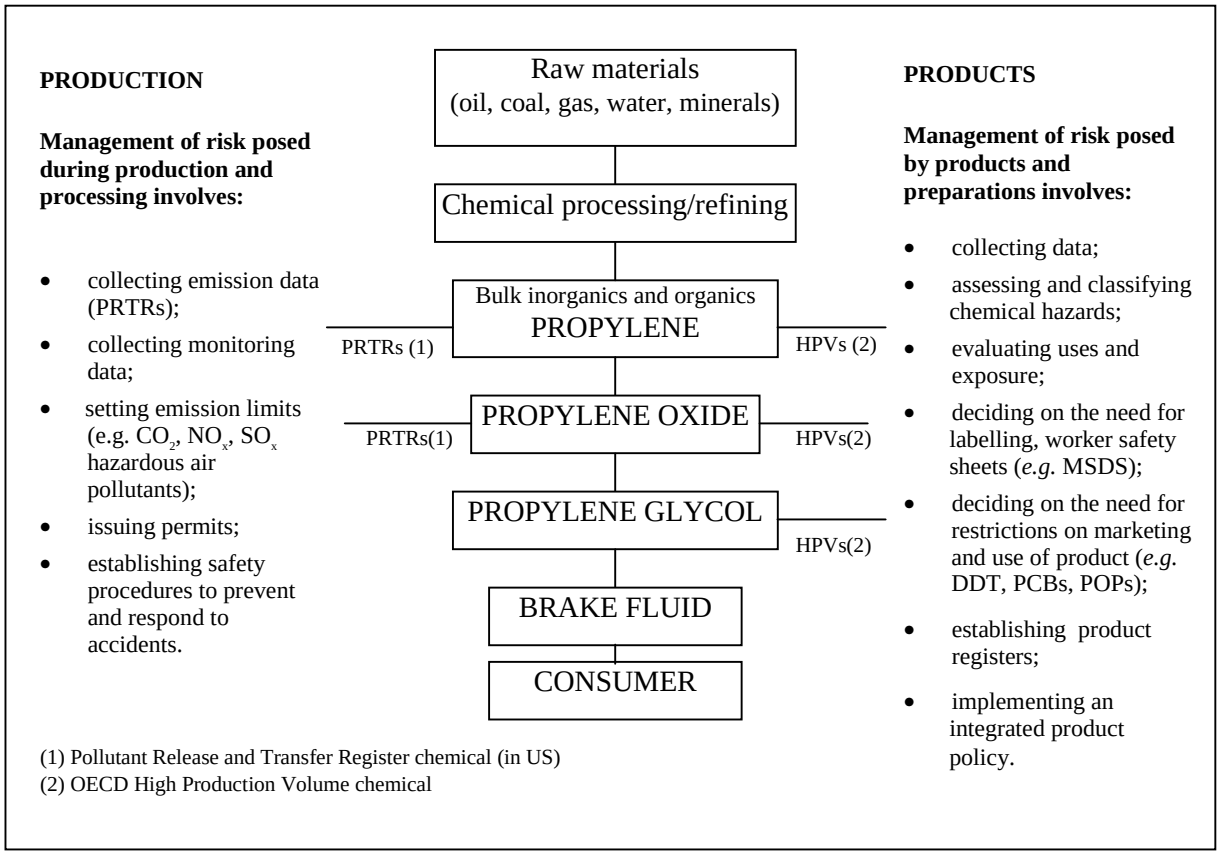
The chemicals industry has developed extensive programmes to reduce plant emissions and waste, and they have invested, and continue to invest, considerable sums of money in environmental protection. In 1990, Western Europe's chemicals industry spent close to US$2.8 billion (10-15% of its total investments) on activities related to environmental protection (UNECE, 1990). CEFIC (1998) reports that since 1990 the EU chemicals industry has devoted between 4% and 5% of its sales to health, safety and environmental protection. In the US, total capital spending of the chemicals industry on environmental, health and safety issues in 1998 was, on average, 6% of sales for small and medium sized companies, and 4% for large companies, (CMA, 1998b). Despite lower profit margins in the US, chemical companies are maintaining capital spending for environmental protection. In Japan, the chemicals industry invested heavily in pollution-control equipment and facilities during the 1970s, and since 1990 has consistently invested between US$0.3 - 0.4 billion which is approximately 0.4% of sales (JRCC, 1998). Across OECD countries, *all* private sector pollution abatement and control expenditures generally amount to between 0.5 - 0.9% of GDP (OECD, 1998c).

5. ENVIRONMENTAL HEALTH AND SAFETY POLICIES

5.1 Overview

This chapter discusses policies to protect man and the environment from both the hazardous emissions that arise during the *production* of chemicals and from the risks posed by chemicals and chemical *products* which are manufactured by the chemicals industry. There are basically two types of policies (see Figure 21) used in OECD countries. The policies which control *emissions* to air, water and soil by facilities that manufacture chemicals are similar to those in place for other industries (*e.g.* reporting on emissions, setting emission limits, permitting emission rates, waste management). The chemicals industry is also subject to implementing polices that are specific to this sector as concerns the prevention of accidents or occupational hazards involving the release of chemicals during their production process. Finally, the chemicals industry makes *products* which by their nature interact directly or indirectly with the environment or the human body and are thus subject to policies meant to limit the risks they pose. Section 5.2 discusses policies and instruments which have been used to control emissions and wastes that arise during the production of chemicals (as well as during their transport, storage and processing into other products). That section also examines policies and instruments for preventing and responding to accidents and comments on their success. Section 5.3 deals with policies for managing the risks of chemicals and chemical products themselves (*e.g.* collection of data on hazard and exposure, safety sheets, labelling, marketing and use restrictions) which have been more or less successful depending on the substance concerned.

Figure 21
Policies for managing the risks from production of chemicals and chemical products in OECD countries



In managing the risks of production processes or products, a mix of policy instruments has been used by national governments, local authorities, industry and international organisations to attain the objective of making the chemicals industry and the products it makes safe for man and the environment. Three broad categories of environmental policy instruments have evolved over the past 30 years and all are being applied, in one form or another, to the chemicals industry in OECD countries:

– *Regulatory instruments* (*e.g.* pre-market approval, emission standards, labelling, product bans) whereby public authorities mandate the environmental performance to be achieved, or the technologies to be used, by companies;

– *Economic instruments* (*e.g.* taxes, tradable permits, refund systems) whereby companies or consumers are given financial incentives to reduce environmental damage; and

– *Voluntary instruments* (*e.g.* voluntary codes such as Responsible Care, ecolabelling schemes) whereby companies make commitments to improve their environmental performance beyond what the law demands.

Regulatory instruments have traditionally been used most often in chemicals management and will be addressed in detail later in the report.

The use of *economic instruments* to reduce environmental damage has grown over the last three decades. In the early 1970s, when environmental policies were in their infancy, economic instruments were seldom used and were subject to much controversy. Since then a slow, but continuous evolution has taken place - they are being used more frequently and there is a greater variety of types of instruments. The main instruments now in use are charges, environmentally related taxes, tradable permit systems, deposit-refund systems, non-compliance fees, performance bonds, liability payments, and subsidies for environmental protection. Different countries tend to favour different approaches, but at some point the chemicals industry is probably subject to most of these types of instruments. So far evidence of the environmental effectiveness of economic instruments is limited, but positive (OECD, 1999b). The main uncertainty is due to insufficient knowledge about how to interpret the impacts of these instruments. Most of them are used in combination with other policy instruments such as standards, voluntary agreements and information and education campaigns, and many of these were already in place when economic instruments were introduced.

Voluntary approaches to improving environmental performance first appeared in OECD countries during the 1960s and the early 1970s and are now being used quite extensively by the chemicals industry. They have been developed by policy-makers and industry to provide pragmatic responses to new environmental problems (OECD, 1999c).

From the perspective of industry, voluntary approaches can provide a flexible alternative to regulations, and may reduce the uncertainty over environmental initiatives that governments may take in the future. These approaches are attractive to governments because they can reduce the often lengthy negotiation process involved in promulgating formal regulations. Industry favours voluntary approaches also because they are normally not prescriptive about how industry should meet targets (although regulatory instruments can also be non-prescriptive), and they can improve the industry's public image. More important, voluntary approaches make it possible to take policy initiatives in environmental areas where regulatory or economic instruments alone may not suffice (*e.g.* energy conservation, waste management). However, for voluntary instruments to be successful, it may be necessary to implement regulations - at the same time the voluntary approach is undertaken - to ensure that set targets are met.

A 1996 OECD workshop on non-regulatory initiatives for chemical risk management (OECD, 1997a) found that voluntary approaches worked best when clear objectives are set and stakeholders are involved early on in the process of designing the approaches and agree on targets, baselines and measurement techniques for ensuring that progress has been made. (A number of successful non-regulatory initiatives are described in Annex 19.)

5.2 Policies for managing risks posed by the production of chemicals

The chemicals industry is one of the most regulated of all industries. In addition to the regulation of its products (see section 5.3), it is subject to a number of requirements aimed at minimising the release of chemical substances to the environment during manufacturing and processing. Such requirements typically include limitations (through regulations) on the amount of a substance that can be released to the environment. Companies can also be required to get authorisation (through permits) for each plant to operate, provided certain conditions are met. These requirements can call for limitations on the release of pollutants from processing operations, or for the use of the best available technology for controlling emissions. These requirements can be set by national, regional or local authorities.

In order to determine whether certain limitations on emissions from factories are necessary, or to determine whether existing limitations are sufficient, data are needed on the releases of pollutants to the environment and the concentration of such pollutants in environmental media.

Public right to know and information collection through emission inventories

Over the last ten years, more and more governments have taken the initiative to bring the public and workers more closely into discussions about ways to protect the environment and attain sustainable development. To do so, the public must be provided with comprehensive and understandable information about the state of their environment and activities which could impact on the environment. Chapter 19 of Agenda 21 – which was adopted at the UN Conference on Environment and Development (UNCED) in Rio de Janeiro - affirms that environmental issues are best handled with the participation of all concerned citizens and that each individual should have appropriate access to information relating to the environment. Chapter 19 says that the broadest possible awareness of chemical risks is a prerequisite for chemical safety and that *each individual shall have appropriate access to information concerning the environment that is held by public authorities, and the opportunity to participate in decision-making processes and that countries shall encourage public awareness and participation by making information widely available*. The principle of the public's and workers' right to know about these risks should be recognised but balanced with industry's right to protect confidential business information. Many OECD countries have now incorporated into their national environmental programmes the principle of community and worker right to know. Industry has also responded by developing mechanisms for education and outreach in the communities where they operate through, among other things, community advisory panels.

Stakeholder involvement in the process of chemical risk management decision-making can be critical. Experience of OECD countries has shown that any decision is likely to affect a wide range of stakeholders. Some stakeholders may, for example, face significant costs as a result of a risk management decision, while the benefits of that decision may be distributed more widely across several different stakeholder groups. By involving stakeholders in the decision-making process - and ensuring, as far as possible, that they understand the issues being addressed - the process becomes more direct, more transparent, and potentially less contentious. In addition to the affected industrial sectors, stakeholders are likely to include government departments, business, organised labour and workers, environmental groups and other non-governmental organisations (such as consumer groups) (OECD, 2000e).

One main tool used by governments to provide data and information to the public about releases of potentially hazardous substances to air, water and soil, and about their transfers off-site for treatment or disposal, is a Pollutant Release and Transfer Register (PRTR). PRTRs - or emission inventories - are environmental management tools that have proved to be an invaluable resource for tracking trends in the chemical and other industries, identifying trouble spots and setting priorities for pollution prevention. PRTRs can provide important information for many different people:

The many different uses of Pollutant Release and Transfer Registers

Governments can use them to:

- set quantitative environmental targets and monitor the success of environmental policies;
- monitor progress towards targets and commitments to international agreements and conventions; and
- improve pollution prevention, recycling, recovery and re-use technologies.

Industry can use them to:

- stimulate more efficient use of chemical substances by identifying material loss (= lost revenue);
- provide a template for environmental reporting under ISO 14000 and complement 'Responsible Care' programmes; and
- improve internal auditing.

The public can use them to:

- learn about their local environmental situation and possible exposure;
- be an informed participant in environmental decision-making; and
- learn more about the environmental behaviour of a company they are considering for investment.

Pioneered by the US Toxics Release Inventory (TRI) established in 1986, the development of emission registers has gained momentum since UNCED. Chapter 19 of Agenda 21 called on governments to implement and improve databases about chemicals, including emissions, and to do this in co-operation with industry and the public. PRTRs have since been established in Australia, Canada, Ireland, Japan, Korea, Mexico, the Netherlands, Norway, the Slovak Republic and the UK, although specific information on emissions from the chemicals industry may not yet be easily accessible from all of them.

Emission Registers: gaining momentum

Argentina, Belgium, Cuba, the Czech Republic, Denmark, Finland, Hungary, Kazakhstan, Nicaragua, Poland, the Russian Federation, South Africa, Sweden, Switzerland, Thailand, the Ukraine, Uzbekistan, Zambia and the EU, among others, are now taking steps to develop emission registers.

OECD Guidance Manual on PRTRs

As a follow-up to UNCED, OECD was asked in 1993 by its Member countries and UN organisations involved in implementing Chapter 19 to prepare a Guidance Manual for use by governments considering establishing PRTRs. Since this document was published in 1996, the OECD programme has focused on providing technical tools (*e.g.* release estimation techniques) for governments and others in order to make their PRTRs as effective as possible.

Through the North American Commission for Environmental Cooperation (CEC), which was established as part of the North American Free Trade Agreement (NAFTA), PRTR data from Canada and the US are compiled annually into a report that provides an analysis of the multi-national data. The CEC report will include Mexican PRTR data in the future. The CEC is also developing a searchable Internet site, which will contain site-specific and chemical-specific release and transfer data for North America. Europe is taking similar steps to provide multi-national emissions data. The European Pollutant Emissions Register (EPER) will collect site-specific and pollutant specific-release data from its 15 Member states.

As seen in Chapter 4, in regions where PRTR reporting requirements have been established for several years, emission levels to air, water and land have been declining. Other PRTRs, which

have been in operation for a shorter period of time, can be expected to demonstrate a comparable trend.

A guidance manual to help countries establish PRTRs was developed and published by OECD (OECD, 1996a), and a co-ordination group has been established under the Inter-Organisation programme for the sound Management of Chemicals (IOMC) to improve co-operation among all international organisations, governments and other interested parties involved in PRTR development.

At present, each country designs its PRTR systems to meet specific national needs. Canada, for example, requires facilities to report detailed information on air releases (*i.e.* fugitive air releases, and air releases from stacks and spills, and from storage and handling), and on water and land releases, and on transfers. Norway requires facilities to report on-site waste management activities. The US collects data on the waste treatment steps for each waste stream containing reportable chemicals. In Australia, facilities may report the reasons for decreases or increases in releases, using check boxes for different pollution prevention or pollution control activities undertaken during the reporting year.

An important consideration for PRTR systems is that facility-specific release and transfer data provide only part of the picture. Small, local or mobile sources can be significant sources for releases of the chemicals on the national PRTR list. The Netherlands and Australia collect estimations of these emissions, thus providing a more comprehensive assessment of national emissions. Other countries, including Japan, are taking steps to add non-point emissions data to their PRTR systems.

The use of PRTR data in exposure assessments is one example of how national and regional governments, industry and the public are integrating PRTR data with other information for different environmental management results. Another example is the use of PRTR data to help the public identify potential risks. The US EPA, for example, has developed a risk-screening environmental indicators (RSEI) model that the public can use as a tool to assess potential risks from releases to air and water. Rather than providing just total volumes of releases for each chemical, this model allows a user to put such data into a limited risk context by integrating potential toxicity with estimated exposure. This is one of a number of tools that allow users to screen for potential risk. (For further information on the RSEI model, see http://www.epa.gov/opptintr/env_ind/index.html.)

Determining environmental burden

ICI (Imperial Chemical Industries) believe that an Environmental Burden (EB) method provides a more meaningful picture of the potential impact of their emissions compared with simply reporting the weights of substances discharged. This calculation method involves the following stages:

- assign individual emissions to air and water to a set of global impact categories;
- assign a factor, from the scientific literature, to each emission that reflects the potency of that substance to impact in a given category;
- multiply the weight of each emission by its potency factor to calculate its EB within an environmental impact category; and
- add together the EB values of all emissions in each category to obtain the ICI Group EB value for that category.

Using this approach, ICI's targets were to reduce the environmental burdens by 50% by the year 2000. This has already been achieved in three out of four areas (ICI, 1998).

The chemical company ICI has developed an approach to prioritise chemicals for environmental management. ICI uses PRTR data with toxicity data in order to make internal decisions concerning each chemical (see box).

Environmental Defence in the US has developed a web site (http://www.scorecard.org) which provides reports on many important pollution problems in the US and helps identify environmental priorities for communities. Information can be obtained by geographic area or by company.

Information collection through environmental monitoring

Environmental monitoring programmes provide a considerable amount of data on actual concentrations of chemicals in the environment, which could be used for various purposes (*e.g.* water management, chemical risk assessment, regulatory compliance, policy development and evaluation). In order to utilise them as much as possible, significant efforts have been made by several organisations to establish regional or global networks for systematically collecting monitoring data beyond national boundaries.

One such system is the European Union's *European Environment Information and Observation Network* (EIONET). EIONET is a collaborative network of the European Environment Agency (EEA) and its Member States, connecting National Focal Points in the EU, nine European Topic Centres, National Reference Centres, and others. The information is used for making decisions for improving the state of the environment in Europe and making EU policies more effective. The UN Global Environment Monitoring System (GEMS/Water) is an international programme on freshwater quality and it has been implemented by several United Nations agencies in co-operation with a number of organisations around the world. Monitoring data gathered via the process of GEMS/Water have been utilised as a basis for identifying regional and global water resource management problems.

Despite these efforts, improvements are needed to make environmental monitoring data more widely available (OECD, 2000c). The Internet could be a powerful tool for doing so. In addition, since ongoing environmental monitoring programmes have mainly focused on well-known environmental pollutants (*e.g.* PCBs, DDT), information needed for exposure/risk assessments on other chemicals is usually not available. A recent study conducted by the US EPA shows that their environmental monitoring data sources currently cover only a small proportion (*i.e.* a range of 0% to 8.6%) of high production volume industrial chemicals in the United States (OECD, 2000d). Among OECD countries, Japan may be the only country which tends to rely on environmental monitoring data when evaluating risks of industrial chemicals. According to their General Inspection Survey, from 1974 to 1995, 287 chemicals out of 752 addressed in the Survey have been detected in the environment (OECD, 2000c). Based on the outcome of the Survey, regulatory actions have been taken, including bans on manufacturing and limitations on production volume.

Management of releases from factories

Specific chemicals

As mentioned above, chemical plants are, for the most part, subject to the same environmental management requirements as other industries (*e.g.* emission limitations on releases, permits). Legislative/regulatory programmes, as well as voluntary programmes, have been instituted for managing the releases of certain substances and ensuring overall environmental performance.

With respect to *specific substances*, the chemicals industry in OECD countries is typically subject to laws, directives or regulations that cover:

- hazardous and non-hazardous waste (for generation, storage, disposal);
- facility and transport accidents;
- discharges to surface water and underground injection of liquid wastes; and
- releases of hazardous and other pollutants (*e.g.* CO_2, NOx) to the atmosphere.

In addition, there are international agreements which govern chemical releases such as the UN-ECE Long-range Transboundary Air Pollution Convention, the Oslo-Paris (OSPAR) Convention for the Protection of the Marine Environment of the North-East Atlantic and the Basel Convention (to control the international movement of hazardous waste) (see Annex 20).

Over the last decade, as OECD countries have explored new and innovative ways to reduce the releases of specific hazardous substances to the environment and to do so at lower costs, many have turned to government-industry partnerships. Negotiated agreements are used extensively in some OECD regions to reduce the releases of certain pollutants (see Annex 19). In the EU, a large number of negotiated agreements exist with the most polluting industrial sectors (metals, chemicals and energy), and almost one-third of these are with the chemicals industry (OECD, 1999c). They are used for all types of pollution, although the two main issues addressed are waste and climate change. Negotiated agreements in the EU may or may not be legally-binding, although they are always legally-binding in the Netherlands where they constitute the key instrument of Dutch environmental policy.

Other approaches include "public voluntary" programmes. In the US, the 33/50 Program is one of the success stories of the voluntary partnership programmes established between the US EPA and industries. The overall goals have been to reduce national pollution releases and off-site transfers of 17 priority chemicals and to encourage pollution prevention. The specific goal was to reduce releases and transfers of the 17 chemicals by 33% by the end of 1992 and 50% by the end of 1995. Both goals were reached one year ahead of schedule. The 17 priority chemicals were chosen on the basis of three criteria: common industrial use, concerns for toxicity and environmental effects, and opportunities for pollution prevention.

The Canadian ARET (Accelerated Reduction/Elimination of Toxics) Program is similar, with participants using the programme to prioritise release reductions, determine appropriate reduction and elimination methods and to voluntarily set release reduction targets. Launched in 1994, the goal is to reduce releases of 30 persistent, bioaccumulative and toxic (PBT) substances by 90% and to reduce releases of a further 87 toxic substances by 50% from base year levels to the year 2000 (ARET, 2000). Virtually all Canadian companies in the chemicals industry are taking part. As of 1998, participants from all the industry sectors involved had reduced annual toxic substance releases by 67% from base year levels and 136 facilities had met or exceeded their year 2000 targets. In addition, releases from the chemicals industry were reduced by 78% from base-year levels. Environment Canada (1999) reports that releases of ARET substances by non-participating sectors are growing while those of participating sectors are falling.

Environmental management systems

An environmental management system (EMS) covers those areas of the overall management system of a company that affect environmental protection: organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining environmental policy. ISO 14001 is an EMS standard. It creates a framework for self-regulation at the company level and provides guidelines on how to implement six core elements for establishing and maintaining an EMS.

Each year, more chemical companies are integrating ISO 14001 requirements into their normal operations. As of May 2000, ISO 14001 certificates worldwide totalled around 17,000 which represents a 76% increase since April 1999 (Hillary, 1999); however, it is not known how much of this percentage is attributable to the global chemicals industry. According to the Japanese Industrial Standards Committee, the number of ISO 14001-certified sites in Japan was 3,693 as of 30 April 2000. The chemicals industry there accounts for 9.5% (350 sites) of these sites, and is the second-ranked industrial sector (JISC, 2000).

In addition, European chemical companies are complying with the European Eco Management and Audit Scheme (EMAS). EMAS, adopted as a regulation by the European Council in 1993, establishes a voluntary environmental management scheme, based on harmonized guidelines and principles throughout the European Union. For a company to register in the scheme, it must adopt a company environmental policy containing the following key commitments: compliance with all relevant environmental legislation, prevention of pollution, and achieving continuous improvements in environmental performance. As part of EMAS, all participating countries have created review mechanisms by which compliance with EMAS is validated by independent, accredited verifiers. As of September 2000, there were 2,784 EMAS sites in Europe and, of this total, 140 were chemical facilities (Buchbinder, 2000). In 1997, 140 German chemical sites had a verified EMAS system (up from 59 in 1996) and the number is expected to grow (ILO, 1999).

While good progress has been made in complying with such systems, some have raised concern about their effectiveness, particularly with respect to ISO 14001 which is based on self-declaration by industry and only calls for the establishment of environmental management systems, and not for specific environmental improvements.

5.3 Policies for managing risks posed by chemicals and chemical products

The products made by the chemicals industry cover an extremely wide range and are used in virtually all consumer products and industrial processes. The discussion of policies for the management of chemicals and chemical products in this report is limited primarily to industrial chemicals, pesticides and biocides, with minor references to pharmaceuticals, cosmetics, food and feed additives. Governments manage the potential risks of chemicals mostly through regulatory frameworks that deal with certain uses of chemical products (*e.g.*, pesticides, cosmetics, pharmaceuticals). Historically, the sectoralisation of competencies among government ministries of health, environment, agriculture and industry has also played a role in determining policies, as well as in their implementation and enforcement.

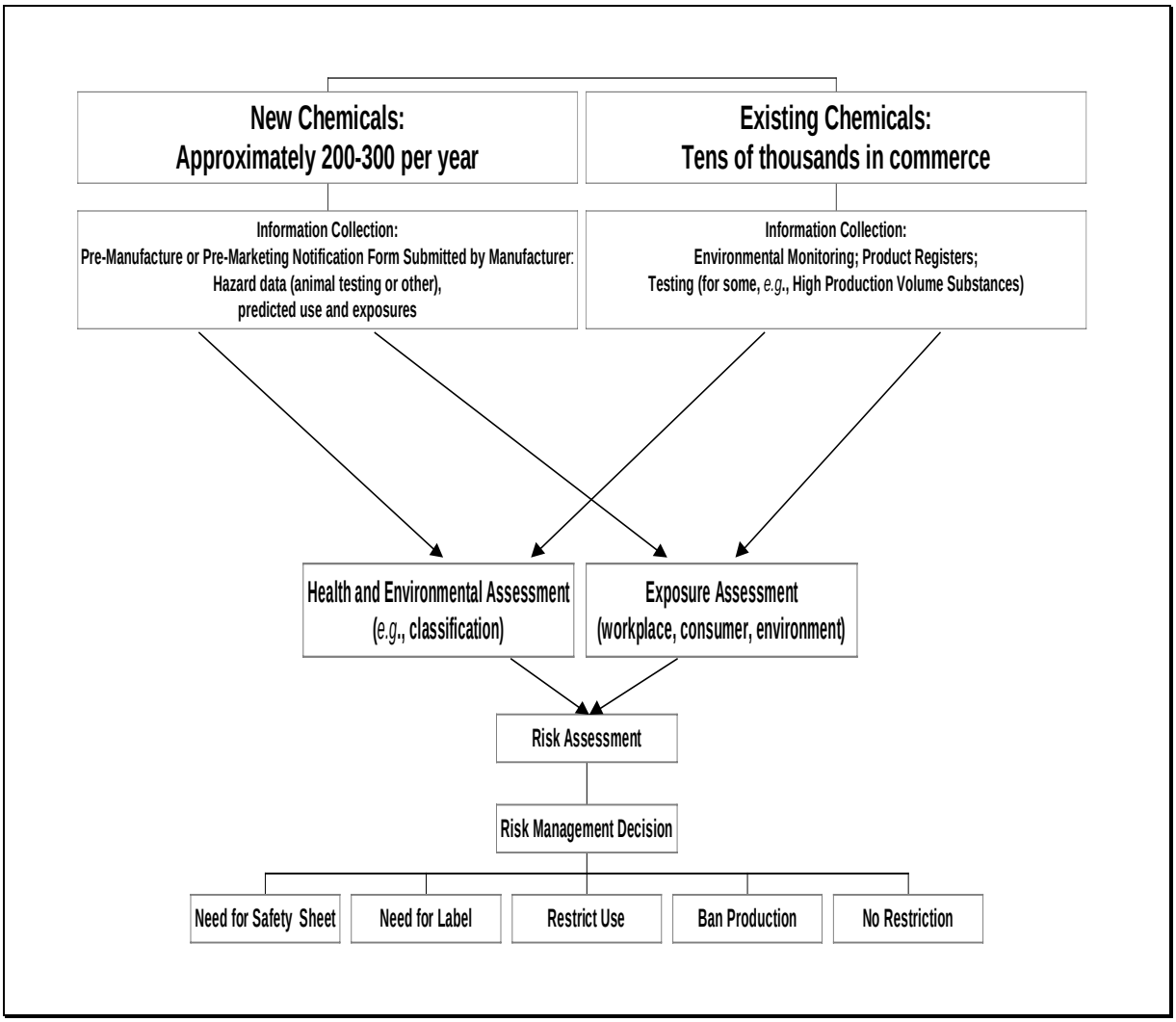
Processes for managing products

Regardless of whether a substance is an industrial chemical, pesticide, pharmaceutical or other chemical product, and regardless of whether it has been in existence for many years or was just designed and the manufacturer is seeking government approval, each country follows a similar approach for managing risks (see Figure 22). First, information is collected either from the manufacturer of the substance, from monitoring data (for existing chemicals), or from the literature. This can include animal test data, predicted environmental or health effects from models, real or predicted exposure levels, *etc*. Based on this information, a government can determine what actions, if any, are needed to manage the risks posed by the substance. Such strategies should deal with risks to all environmental media and human health, as well as with those arising at every part of a chemical's lifecycle - from its initial conception to final disposal.

Collecting information on characteristics, effects and exposure

Obviously, in an ideal world, no chemical or chemical product would be able to be marketed or used in consumer goods without enough information being available for governments to make informed decisions on its acceptability for use, taking the chemical's or product's complete lifecycle into account. Great efforts have been made to develop the content of minimum information packages necessary to assess chemicals, and to develop methodologies and processes for evaluating this information and using it for decision-making. Attempts to get access to useful information have been more or less successful, depending on the group of chemicals and regulatory frameworks that are involved.

Figure 22
Approaches for managing risk



In order to predict the environmental or human health hazard of a chemical, governments sometimes rely on predictions based on (Quantitative) Structure Activity Relationships, but in most cases they rely on laboratory test data and models. The endpoints covered by these tests and models can include physical and chemical properties, effects on human health and wildlife, and accumulation and degradation in the environment. Depending on the type of chemical, the information needed can be quite substantial, particularly for agricultural pesticides and biocides. Such data may exist in the open literature or industry files or may need to be generated. Testing can be very resource intensive and time consuming and, if it is repeated each time a chemical is registered in a different country, duplication and unnecessary use of animals can result. OECD countries therefore endorsed a 1981 OECD Council Act on the Mutual Acceptance of Data (MAD) which encourages the sharing of test data (see box).

MAD, OECD Test Guidelines and GLP

The 1981 OECD Council Decision on the Mutual Acceptance of Data (MAD) strongly encourages use of the OECD Test Guidelines (a collection of methods used to assess the hazards of individual chemicals and of chemical preparations, such as pesticides) and of GLP Principles (standards for managing laboratories and for performing and reporting studies). This Council Act requires OECD governments to accept test data developed for regulatory purposes in another country if these data were developed in accordance with the Test Guidelines and GLP Principles. This means that new data do not have to be developed for notification or registration of the same chemical in each OECD country. A Council Decision of 1989 gives the standards for national authorities with respect to monitoring of compliance with GLP. Since 1997, the system has been open to non-OECD countries as well.

MAD increases the efficiency and effectiveness of chemical notification and registration procedures for both governments and industry. It ensures high-quality test data and a common basis of information for assessing risks. It also helps to promote animal welfare by avoiding duplicative testing. For industry, Mutual Acceptance of Data means that the same set of studies will be accepted by all OECD countries (and most other countries as well), saving a considerable amount of time and money.

For some existing substances, actual monitoring data which portray exposure levels to either workers or the environment may exist. Unfortunately, this is not often the case. Governments typically rely on surrogates for exposure data such as information on production levels, emission registers, and information about the structure or characteristics of a chemical which can be used to predict exposures by using models.

Hazard characterisation, classification and risk assessment

Information gathered through testing is used to characterise the potential hazard of a chemical. Based on the physical-chemical properties, environmental fate (degradation/accumulation) and the hazardous effects identified, chemicals and chemical mixtures can be classified into different categories (*e.g.* “hazardous to aquatic environment”, “corrosive to the eye”, “carcinogenic”, “reproduction toxicity”). National and regional schemes for the hazard classification of chemicals and mixtures have existed in many OECD countries for some years, and there are classification-based UN recommendations on the transport of dangerous goods. Because the existing schemes were developed independently there are differences between them that complicate international business and trade in chemicals. At the United Nations Conference on Environment and Development in 1992, it was recognised that these differences were more likely to lead to confusion than to ensure safety and an IOMC activity was initiated to harmonize classification and labelling systems to arrive at a Globally Harmonised System (GHS). Under the umbrella of the IOMC (see Chapter 7), OECD took the lead to

develop harmonized classification criteria for human health and environmental hazards, while the UN Committee of Experts on the Transport of Dangerous Goods (UNCETDG) took the lead to harmonize classification criteria for physical-chemical hazards, and ILO lead the work on hazard communication. Almost all of the classification criteria have now been agreed. The completed hazard classification systems, accompanied by their labels and other communication tools, will be implemented through the United Nations. It is currently expected that all countries will have the GHS fully operational by 2008.

The information gathered on potential exposure of man and/or the environment to a chemical can be combined with that on health and environmental effects and evaluated to draw conclusions about the risk of the chemical. There are various approaches and methodologies for risk assessment, but their objective remains to provide sufficient information about a chemical to be able to take any necessary action regarding its production, use and/or disposal.

Risk management

The management of risks caused by chemicals and chemical products can be done through a wide range of instruments which can be voluntary or regulatory in nature and which can be applied nationally, regionally or globally; often a mix of these instruments is used. These actions can include providing information to users of a product (*e.g.* safety sheets for workers handling a substance or product labels for consumers), restricting certain applications of a product, or completely banning its production, import and export. Such controls can exist at both the national and international level.

Regulatory instruments have often been used in chemicals management. Governments have traditionally used safety sheets (*e.g.* MSDS) and labels as a way to ensure the products are properly handled and exposures minimised. However, the requirement for such labels can also promote the production of safer chemicals since companies would prefer not to have to label their products as hazardous. Similarly, information about a product's content of hazardous substances is essential in allowing downstream users and even consumers to make informed choices when purchasing products. Those who buy large quantities of chemicals on a commercial basis are in a position to make demands on producers and suppliers concerning the environmental profile of their products.

Bans – the severest regulatory limitation possible – have been applied almost exclusively to chemical products. PCBs, phosphate detergents, asbestos, DDT and other pesticides, TBT, leaded gasoline and chlorofluorocarbons (CFCs) are the main examples. Each presented a major environmental and/or human health hazard – often global in scale – to which countries responded in unison. Product bans and phase-outs always bring about a change in technology, creating alternatives for specific uses and needs. The nature of the change can range from simple substitution of readily available products, processes or components (*e.g.* aqueous cleaning replacing CFCs) to incremental innovation (reformulated detergents or gasoline) to radical innovations that can restructure whole industries (PCB substitutes produced by new firms which totally displaced the sole US producer).

A number of international conventions have been - or are being - established to address chemicals issues (see Annex 20). These agreements were introduced when the regional and global nature of many of the potential impacts of chemicals on the environment began to be widely recognised. For example, the Montreal Protocol (1987) and the Convention on Persistent Organic Pollutants (not yet ratified) aim to reduce or eliminate the emissions, and sometimes the production, of hazardous chemicals. Others, like the Rotterdam Convention for Prior Informed Consent (1998), are designed to control international movements of hazardous chemicals. The Rotterdam Convention should help limit the use of hazardous chemicals to applications where they are absolutely necessary

and can be used safely, and help prevent new chemical safety problems. Perhaps if the Rotterdam Convention had been in place earlier, the build-up of obsolete pesticide stocks, which is a problem in many non-OECD and some OECD countries, could have been avoided.

The approaches for establishing such controls vary across countries and regulatory agencies. In general, though, governments: (i) identify the risks; (ii) specify initial risk management options to be considered; (iii) identify the key impacts which should be evaluated (*e.g.* costs to producers and consumers of any action; human health and environmental benefits); and (iv) consider implementation approaches (voluntary, mandatory, use of economic instruments) and then choose the most appropriate.

For those substances requiring some form of risk management, more and more countries are using *voluntary negotiated agreements* (between government and industry). For instance, a number of countries have worked with farmers to reduce pesticide use by setting reduction targets (OECD, 1996b). Negotiated agreements have also been used in some countries to phase-out certain products (*e.g.* arsenic, chrome, PBBs).

The chemicals industry itself has also taken unilateral approaches to manage the risks posed by the chemicals they produce. The Responsible Care programme is viewed by many as being one of the most important developments in this area in the last 20 years. Responsible Care is the industry's voluntary commitment to continuous improvement in all aspects of health, safety and environmental performance, and to openness in communication about its activities and achievements. Initially developed in Canada in 1984, the Responsible Care programme was taken up by the International Council of Chemical Associations (ICCA) in 1991. Today, national chemicals industry associations in 46 countries representing 87% of global chemicals production by volume (ICCA, 1998) have committed themselves to Responsible Care. An important component of Responsible Care is product stewardship whose purpose is to prevent injury to human health and damage to the environment through all stages of a product's lifecycle. Product stewardship therefore includes the initial concept, design, research and development, manufacture, storage, distribution, applications, reasonable foreseeable use, recycling and disposal of a product. Product stewardship requires co-operation among management, employees, contractors and customers and other parties involved in the supply chain (from raw material sourcing through to final disposal) to follow regulations and safe and environmentally sound practices.

While Responsible Care is, and has been, a very useful programme, some consider that it would be helpful if it placed greater emphasis on practical, rather than on conceptual aspects, and looked beyond manufacturing plants. For example, by practising good product stewardship, companies are likely to accumulate information on the use of their chemicals, particularly high production chemicals, and such information should be provided to government authorities to assist in the international assessment of these substances.

Economic instruments are increasingly being used by governments to improve the efficiency and effectiveness of chemical risk management actions. One of the most widely used and significant applications of economic instruments was for the phase-out of leaded petrol. In 20 OECD countries, a tax differential in favour of unleaded petrol was introduced at the same time as a series of other policy measures to encourage substitution of leaded with unleaded petrol (OECD, 1997c).

Reductions in the production of Ozone Depleting Substances (ODS) were achieved by concerted action at the global level through the Montreal Protocol and with the help of economic instruments. The Protocol came into force in 1989 with the objective of eliminating ODS following agreed timetables. Governments and industry have worked well together using a variety of

environmental policy mixes to develop alternatives or substitutes for ODS, recover and recycle ODS, and regulate emissions. Some OECD countries are using economic instruments (OECD, 1999b). Australia, the Czech Republic, Hungary and Iceland, for example, are applying incentive charges to support programmes for phasing out these substances, to finance their disposal (Iceland), or to constitute an environmental fund (Hungary). In Australia, the revenues are used for administration and awareness programmes, while in the Czech Republic they are used for abatement. Canada and the US apply tradable permits.

As mentioned above, when there is concern over the risk posed by the use of a particular substance, a range of actions can be taken to reduce this risk. Such actions are not without costs. These may include increased production costs to industry and higher end product costs to consumers. Because the resources spent on reducing one risk cannot be spent on others, it is important that efforts are focused on managing the most significant risks. To do so, OECD countries are increasingly applying socio-economic analysis to chemical risk management to ensure that the right decisions are made.

Choosing the right risk management option

In 1998, OECD launched a new initiative to help guide governments in developing socio-economic analyses (SEA) of risk management options. To date, two guidance manuals have been developed on: (1) how to integrate SEA into chemical risk management decision-making; and (2) how to conduct retrospective studies of such analyses to determine how well *ex post* impacts correspond to *ex ante* predictions made in completed SEAs.

A 1995 OECD Council Recommendation calls on Member countries to "carry out, early in the regulatory process, an informed comparison of a variety of regulatory and non-regulatory policy instruments, considering relevant issues such as costs, benefits, distributional effects, and administrative requirements" (OECD, 1995). As of 1997, all OECD countries require some form of regulatory impact analysis, with a large number applying both cost-benefit analysis and cost-effectiveness analysis as the basis for such assessments (see Annex 21). It is likely, though, that the level of application of these analyses across the different countries varies widely in terms of both comprehensiveness and reliability of results.

The use of socio-economic analysis can range from an examination of the effect of the application of simple risk management options concerning the limitation of a particular use of a product in one country, to the global impacts of a number of products, like ozone depleting substances (see Table 9).

Table 9
Estimated costs and benefits of a phase-out of ozone-depleting substances over the years 1987 to 2060

Estimated global costs	Estimated global benefits
• US$95,000 million for phase out of CFCs in air conditioning and refrigeration • US$48,000 million to eliminate methyl chloroform • US$33,000 million to eliminate HCFCs • US$19,000 million to eliminate CFC solvents, mainly in the electronics industry • Although initial capital costs were incurred in switching from CFC aerosol propellants to hydrocarbons, the reduced material costs of hydrocarbons will result in savings of > US$5,300 million by 2060	• The following would be avoided: • 19.1 million cases of non-melanoma skin cancer • 1.5 million cases of melanoma skin cancer • 333,500 skin cancer deaths • 129 million cases of cataracts • US$238,000 million worth of damage to the world's fisheries • US$191,000 million worth of damage to agricultural production • US$30,000 million worth of damage to PVC plastic products in the building industry
Net saving:	**US$264,000 million plus the health benefits**

Source: Environment Canada, 1997

Philosophy and implementation of chemicals management policies

OECD restrictions on specific chemicals

A 1973 Council Decision to restrict the use of PCBs marked the first use of concerted international action to control the environmental risks of a specific chemical. Shortly thereafter, a Recommendation was adopted on measures to reduce emissions of mercury to the environment. Work undertaken in OECD on CFCs and lead have resulted in concerted risk management actions among countries.

When governments first became active in adopting policies for controlling the risks of chemicals several decades ago, it was primarily through regulatory action focused on specific industrial chemicals or pesticides which were known to pose important health or environmental problems, such as DDT, PCBs, mercury and CFCs. OECD undertook concerted action to reduce the risks of several of these problem chemicals (see box). By the mid-1970s it had become clear that, with the hundreds of new chemicals and chemical products entering the global market every year, comprehensive, forward-looking strategies were needed to identify and manage their potential risks, as had been the case for specific chemical products which can have a direct impact on human health. Somewhat later, the need for a strategy (and appropriate action) became evident also for the much greater number of chemicals and pesticides that were already on the market and whose potential risks had not been identified (for an overview, see the OECD web site: http://www.oecd.org/ehs/chmabout.htm).

New industrial chemicals

As a starting point, to determine the number of chemicals that needed to be dealt with, OECD governments collected data from chemical manufacturers to establish inventories of chemicals currently being produced. Once this was established, it was possible to define what was "existing" (on the inventory) and what was "new" (not on the inventory). Countries then required that a new chemical would have to get government approval before it could be put on the market.

Pre-market notification and registration/approval systems for pharmaceuticals, pesticides/ biocides and industrial chemicals have been instituted in most OECD countries and many developing countries already have established them or are in the process of doing so.

All new industrial chemical schemes in OECD countries have certain common elements. First, each is based on national legislation, directives, decrees and/or regulations and second, each requires the submission of information on the prospective manufacture or marketing of a new chemical so that the authorities can assess the risks that might be posed by the substance.

Placing a chemical on the market

The OECD Council Act on the *Minimum Pre-marketing Set of Data (MPD)* was developed by a group of experts who were asked to define a base set of data for an initial assessment of the potential effects of chemicals on man and the environment. This set includes recommended data elements and other information which ought to be considered before a decision is taken to put a chemical on the market. It includes information on those physical/chemical properties which can be used to predict how the chemical will behave in the environment, toxicological and ecotoxicological effects, as well as how and to what degree the substance is likely to spread and concentrate in the environment and in biological systems. The MPD also includes information on intended use and estimated production.

Many of the national data requirements of new industrial chemical notification and assessment schemes are based on the OECD Minimum Pre-marketing set of data (see box); however, from country to country there are differences in the data requirements. The major notification schemes in OECD countries differ in the degree of testing that is mandated and in the extent of risk assessment that is carried out (the OECD web site http://www.oecd.org/ehs/NewChem/ contains descriptions of most OECD country programmes). Each government has developed a scheme which it believes to be appropriate for its needs.

Chemicals that are judged to have potentially undesirable effects may not be allowed on the market, and this eventuality can drive chemical companies to develop new chemicals with more environmentally-friendly profiles.

Concerns have been voiced, however, that pre-market approval systems can stifle technological development. For pharmaceuticals, studies in the 1970s suggested that more stringent regulation in the US than in the UK was leading to fewer new drugs being made available. Later studies showed that the picture was not so simple, and that pre-market approval was not so much reducing the number of products coming to the market, but instead was prolonging - and hence increasing the cost of - research and development of new drugs. In response, the US Congress increased the life of pharmaceutical patents to limit these potential disadvantages in the development of new drugs in the US (OECD, 1999a). For new industrial chemicals, the industry claims that the higher cost of notification in the EU (which requires significant testing) compared with the US (which does not) has a detrimental effect on innovation. The European Commission's recent White Paper on a strategy for a Future Chemicals Policy stated that "recent experience has shown innovation (*e.g.* in developing new and often safer chemicals) has been hindered by the burdens of the present notification system" (European Commission, 2001).

Pre-market (manufacturing) approval and registration systems require a clear definition of scope of application and may call for better monitoring and enforcement mechanisms. It has been found in the EU that many new substances have not been reported or identified as such, that their uses have often been improperly recorded and, in some cases, that they have been inadequately labelled (EEA/UNEP, 1998). Recent moves to change policy - such as the current review of EU chemical legislation - indicate that implementing systems to ensure that new industrial chemicals are safe may

take up more than their share of resources currently available through the regulatory frameworks for existing chemicals management.

Existing industrial substances

Prior to the introduction of pre-market regulations, industrial chemicals could be put on the market with very little or no information concerning their potential risks to human health and the environment. The number of these "existing chemicals" on the market is large, although the exact number is unknown. The current estimates for those actually on the market vary widely from 20,000 to 70,000 (EEA/UNEP, 1998).

Not all of these chemicals require the same level of evaluation (*e.g.* those used in very small amounts in closed processing systems may not be considered of high risk). Given the fact that there are a large number of existing chemicals, it may not be feasible to conduct complete and comprehensive testing on each one of them. Therefore OECD identified a minimum package of information - known as the SIDS (see box) - that is needed to make an initial assessment of existing chemicals. A major issue for chemicals managers is the extent to which all existing chemicals should be tested and assessed.

SIDS

OECD countries have identified the data elements needed for screening chemicals to determine whether further work is necessary. The Screening Information Data Set - or SIDS - comprises a limited number of data elements which can give information on the characteristics and effects of chemicals. Similar to the Minimum Pre-marketing Set of Data (MPD) for new chemicals, SIDS is used in the HPV Chemicals Programme by many countries and in voluntary industry programmes.

Attempts to identify and address potential impacts arising from the use and release of existing chemicals are being made through international, regional and national programmes. The starting point for setting priorities for information gathering, testing and assessment among this large number of chemicals has generally been production volume, which is considered to reflect potential exposure. Even for many High Productive Volume (HPV) chemicals no complete SIDS is available. For example, in the EU, only 14% of HPV chemicals have data at the level of the base-set[12], 65% have less than the base-set level, and 21% have no data at all (Allanou, R., *et al* 1999).

The OECD High Production Volume (HPV) Chemicals Programme (see box) and programmes in Member countries are making progress in assessing existing chemicals, but progress is slow. After ten years,

OECD HPV Chemicals Programme

OECD passed a Council Decision-Recommendation in 1987 that stated that its Member countries should establish or strengthen national programmes to systematically investigate existing chemicals. These national efforts were followed up by a second OECD Council Act in 1990 which established a programme on the co-operative investigation of existing chemicals. This programme focuses on chemicals produced in high production volumes (i.e. produced in greater than 1000 tonnes in one OECD country or the European Union) of which there are about 5,000. Little is known about the toxicity for some 75% of these chemicals (EDF, 1997). A minimum set of data upon which an initial hazard assessment can be based for HPV chemicals will be provided by OECD countries in co-operation with industry. The OECD programme is based on the principle of sharing the burden of investigating existing chemicals among the different OECD countries and the chemicals industry.

12. "Base set" are data elements relevant for risk assessment and listed in Annex VIIA of EU Directive 67/548.

about 200 assessments have been agreed. Progress has been constrained by limitations in resources, as well as by policy issues related to differences among the various national/regional programmes participating in the OECD effort. However, the recent refocusing of the OECD programme to concentrate on initial hazard assessment of HPV chemicals, expected changes in EU legislation, and a major voluntary testing initiative from the chemicals industry should improve the situation substantially in the near future. By 2004, gaps in basic human and environmental toxicity data for around 2,800 HPV chemicals are expected to be filled by US industry under the "HPV Challenge Program". 1000 HPV chemicals produced in at least 2 OECD regions are to be assessed by industry *via* an initiative of the International Council of Chemical Associations, of which 500 will also have been reviewed by governments under the OECD programme. If these targets can be reached by 2004, then it should be possible to fill data gaps for the remaining chemicals on the OECD HPV list by 2020, or even much earlier. These initial hazard assessments of HPV chemicals allow for recommendations to be made for further information gathering/testing or assessment work where necessary, and can assist in the management of chemicals as well.

Nevertheless, if the information necessary for properly managing all existing chemicals is to be comparable in quality and quantity to the information that has been gathered and assessed for the much smaller number of new chemicals and chemical products subject to pre-market schemes, then additional screening and priority-setting measures will be necessary to ensure that resources are wisely spent and produce maximum results for protecting man and the environment. First of all, it is imperative to know exactly which chemicals are on the market, in what volumes and, especially important, what they are used for. Resources could then be devoted to assessing those chemicals which have wide dispersive and/or consumer uses, as has been done for those applied directly to the environment (pesticides, biocides, feed additives) or used by humans (pharmaceuticals, food additives, cosmetics). Here, a great deal of information is missing from manufacturers, importers and downstream users of industrial chemicals which could be used as a starting point before going to the next level of information concerning the characterisation and effects of chemicals and chemical products.

Pesticides

Pesticides registration schemes exist in all OECD countries and approval before marketing is required. The data package required for pesticides is much larger than that for new industrial chemicals because pesticides are known to be biologically active and to result in direct exposure of the environment and possibly humans. Over the past several years, the environmental risks of pesticides have been considered much more extensively in granting marketing approval, and they have played a greater role in the decision-making process. Also, more attention is being paid to ensure that there is a real "added value" in terms of the efficacy of new pesticides.

The development and registration of safer pesticide products is encouraged in many countries through a variety of mechanisms, including reduced data requirements for low-risk biological pesticides, reduced registration fees and commitment to faster registration.

Many countries supplement their pesticide registration programmes with re-registration programmes to bring the test data on older pesticides up to modern standards. Re-registration has high priority in many countries because knowledge about possible adverse effects has grown considerably during the last three decades, and data requirements and hazard evaluations have become much more comprehensive. Information made available through re-registration programmes has been used by some countries to ban pesticides that were once widely used, such as DDT, aldrin and dieldrin. OECD

has undertaken a major effort to assist Member countries in finding ways to share the burden of the work involved in the scientific review for the registration and re-registration of pesticides.

5.4 Small and medium sized enterprises

The impact from the activities of small and medium sized enterprises - both producers and users of chemicals - on health, safety and the environment, is difficult to determine. First, some SMEs are exempt from regulations due to their size (*e.g.* facilities with less than ten full-time employees are not required to report for the US EPA's Toxic Release Inventory). Second, those that are subject to chemical regulations may not realise this, and thus do not comply with these requirements. Finally, those who do realise they are subject, may have difficulty complying because they lack the technical expertise and/or financial resources to do so.

In some cases, governments may contribute to the problem of non-compliance. When examining the chemical industry, members of the US President's Council on Sustainable Development noted that "many regulations seem to be written with large continuous process manufacturers in mind and they urged EPA to look at the special challenges in complying with these regulations faced by batch chemical manufacturers" (US EPA, 2000d). In response, the US chemical industry and EPA worked together on a pilot project in the state of New Jersey looking at SME batch operators to identify the root causes of non-compliance with regulatory requirements. The most frequently cited reasons were:

1. Insufficient/inadequate resources, including staffing and funding at facilities and compliance guidance from agencies;
2. Companies were unsure *which* regulations apply to them;
3. Companies were unclear *whether* a regulation applies to them and, if so, *how* it applies;
4. Employees did not understand what to do; and
5. Insufficient self-auditing program.

(US EPA, 2000e)

Improving Compliance

Governments and industry need to examine ways to address SME compliance problems. The US state of New Jersey pilot project developed recommendations for government to help improve SME compliance rates with chemicals regulations. These include:

- articulating new regulations more clearly;
- ensuring that federal authorities work with local authorities so that regulations are interpreted consistently;
- pilot-testing new rules;
- providing more incentives for disclosure of violations; and
- working with industry to provide more technical assistance, including guidance documents.

(Chemical Alliance, 1999)

Larger companies and trade associations can also help. Large companies can share their experiences and provide assistance through experts. National federations of chemical industries can issue guidance to, among other things, help SMEs implement Responsible Care, and provide expertise to companies to help them conduct impact assessments, performance evaluations, etc. (CEFIC, 1995)

The Fifth Annual Report of the European Observatory for SMEs (European Commission, 1997) also found that in comparison with their larger counterparts, "SMEs show lower awareness and knowledge of environmental issues, lack of availability of qualified personnel, lack of top management involvement, high compliance costs and scarce financial resources." Similar results were identified in surveys in Australia (NOHSC, 1996).

As there will be a shift of focus over the coming years toward chemical products and uses as they work their way through commerce (*i.e.* beyond the main manufacturing facility), more attention will need to be paid to the impact of SMEs on health, safety and the environment. This will include collecting and evaluating information on such firms as part of product life cycle assessments. Governments will also need to examine ways to engage such firms more in the decision-making process, not only to collect information, but also to improve compliance rates. However, care needs to be taken to balance the benefits of receiving information from SMEs (and including them in chemical risk management activities) with the costs the SMEs will have to bear to carry out such work.

5.5 Holistic approaches to chemicals management

Historically, most of the management techniques used for controlling emissions during the production of chemicals and chemical products could be described as "end of the pipe" solutions in that they dealt with hazards or risks by making relevant information available to the user or by taking action to ban or restrict certain chemicals or applications. Recently, governments and industry have been considering more holistic management approaches which attempt to prevent injury to human health and damage to the environment throughout all stages of a chemical product's lifecycle. Such lifecycle management approaches require that sufficient information on the potential risks involved at each stage of a product's life be made available to each of the parties involved for follow-up, and require that producers exercise oversight and assume ultimate responsibility for their products (*e.g.* through Responsible Care and Product Stewardship programmes).

For companies currently participating in Responsible Care programmes - and for those that are planning to - greater consideration is being given to strengthening the links in the supply chain, from the manufacture of a product to its use and final disposal. But, as industrial associations in different countries have their own guiding principles for such programmes, and some are more ambitious than others, a key challenge for industry will be to develop coherent performance measures for Responsible Care that will indicate to stakeholders whether or not progress is being made.

Recently, the concept of integrated product policy (IPP) has been gaining currency in government and industry. When designing a product and production process using IPP, a company will consider the impacts the product may have on man and the environment throughout its entire lifecycle. Many companies are now looking at how they can incorporate this policy into their businesses operations, and the European Commission recently adopted a green paper which defines a European integrated product policy that can promote sustainable industrial production.

As part of IPP, there have been recent efforts by OECD governments to take measures to extend private sector responsibility for conserving resources and energy, and reducing pollution and waste. Extended Producer Responsibility (EPR) is concerned with the final disposal of products after their sale and use by consumers. The design of a product and product systems is the most critical step in determining the nature and quantity of resource use and pollution outputs throughout a product's life cycle. The types of materials selected by the producer can have a significant impact on the environment with regard to the extraction and processing of the materials, including energy consumption. Under EPR, the responsibility for dealing with a product that is no longer in use is

extended to its producer - a responsibility that has traditionally been held by municipalities and was funded by taxpayers. EPR embodies the principle that manufacturers should bear a significant degree of responsibility for the environmental impacts of their products – including upstream impacts inherent in the selection of materials for the products, impacts from production, and downstream impacts from the use and disposal of the products. The aim of EPR is to shift the physical and/or financial (full or partial) responsibility from municipalities to the product's producer. A key motivation for EPR policy by national governments is that it provides incentives for developing more sustainable and less wasteful products, resulting in less waste requiring disposal, reduced raw material use (amount of raw/virgin material input per unit of product) and increased resource efficiency. OECD has developed guidance material for the application of EPR.

Similarly, governments are working with industry to develop policies that will lead to the design of chemicals that are safer for man and the environment than those in existence today (see Chapter 7). Government "sustainable chemistry" programmes, with support from the OECD, are identifying policies to promote research and other work that will help companies create these new chemicals.

The movement toward a more service-oriented economy also has implications for better managing risks along the entire lifecycle of a product. Companies (both suppliers and customers) are focusing more on the *function* a product can provide than on the *product* itself in order to find better and cheaper ways of achieving business goals. For example, DuPont is working with Ford UK in its painting operation. DuPont will do the actual painting and will be compensated on a per-car basis rather than on the number of gallons of paint sold. Similarly, Dow Europe provides a chlorinated solvents service which delivers, recovers, and reclaims used solvents from its customers (White *et al*., 1999). By being involved and taking responsibility for a product further down the supply chain than normally is the case (*i.e.* from production, to use, to recovery and disposal), a company can consider all environmental impacts when first designing a product and its use.

5.6 International chemicals management

With greater trade in chemical products, and the growing recognition that pollutants travel across national borders, the last three decades have seen an increase in international efforts by governments to manage chemicals. A timeline of major regional and international chemical safety activities over the last 30 years is given below in Table 10.

Table 10
Timeline of major regional and international activities on chemical safety

YEAR	ORGANI-SATION	ACTIONS
1971	*OECD*	OECD Environment Committee establishes the OECD "Chemicals Group"
1973	*OECD*	OECD Council adopts Decision on Protection of the Environment by Control of Polychlorinated Biphenyls
1973	*JAPAN*	Enactment of the "Law Concerning the Examination and Regulation of the Manufacture of Chemical Substances"
1973	*WHO*	The WHO Environmental Health Criteria Programme was started
1974	*OECD*	OECD Recommendation on the Assessment of the Potential Environmental Effects of Chemicals
1976	*UNEP*	The United Nation's International Register of Potentially Toxic Chemicals was formed
1976	*US*	Toxic Substance Control Act promulgated
1977	*OECD*	OECD Recommendation establishing Guidelines in respect of Procedure and Requirements for Anticipating the Effects of Chemicals on Man and the Environment
1978	*OECD*	Decision establishing the Special Programme on the Control of Chemicals
1979	*EU*	EC " Sixth Amendment" concerning the control of the introduction and marketing of chemicals in Member states
1980	*IPCS*	The International Programme on Chemical Safety was established as a joint venture of UNEP, ILO and WHO
1981	*OECD*	High Level Meeting of the Chemicals Group
1981	*OECD*	Decision concerning the Mutual Acceptance of Data in the Assessment of Chemicals[13]
1982	*OECD*	Decision concerning the Minimum Pre-marketing set of Data in the Assessment of Chemicals
1984	*OECD*	Recommendation concerning Information Exchange Related to Export of Banned or Severely Restricted Chemicals
1985	*FAO*	Conference of FAO on the Code of Conduct on the Distribution and use of Pesticides
1987	*UNEP*	Montreal Protocol on Substances that Deplete the Ozone Layer
1987	*UNEP*	London Guidelines for the Exchange of Information on Chemicals in International Trade
1987	*OECD*	Decision-Recommendation on the Systematic Investigation of Existing Chemicals
1988	*OECD*	Decision on the Exchange of Information concerning Accidents Capable of Causing Transfrontier Damage
1988	*OECD*	Decision-Recommendation concerning Provisions of Information to the Public and Public Participation in Decision-making Processes Related to the Prevention of, and Response to, Accidents involving Hazardous Substances
1989	*OECD*	Decision-Recommendation of the Council on Compliance with Principles of Good Laboratory Practice[14]
1990	*ILO*	International Labour Organization Convention and Recommendation on Safety in the Use of Chemicals at Work

13. The OECD Test Guidelines and OECD Principles of Good Laboratory Practice Principles are Annexes I and II, respectively, of this Council Act.

14. The Annexes to this Council Act were amended in March 1995 (Decision of the Council Amending the Annexes to the Council Decision-Recommendation on Compliance with Principles of Good Laboratory Practice).

1990	*OECD*	Decision-Recommendation on the Co-operative Investigation and Risk Reduction of Existing Chemicals
1992	*UNEP*	UNCED (Rio de Janeiro, Brazil) adopts "Agenda 21", including Chapter 19 on chemicals
1992	*UNECE*	Adoption of the Convention on the Transboundary Effects of Industrial Accidents
1992	*OECD*	Recommendation on the Guiding Principles for Chemical Accident Prevention, Preparedness and Response
1993	*ILO*	ILO Convention and Recommendation on the Prevention of Major Industrial Accidents
1994	*IFCS*	Establishment of the Intergovernmental Forum on Chemical Safety
1995	*IOMC*	The Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) is formed. The IOMC includes UNEP, ILO, WHO, FAO, UNIDO, OECD and UNITAR.
1995	*FAO*	Global Integrated Pest Management facility established
1996	*OECD*	OECD Environment Ministers adopt Declaration on Risk Reduction for Lead
1996	*UNITAR*	United Nations Institute for Training and Research (UNITAR) publishes guidance document to help countries develop National Profiles which assess their national infrastructure for management of chemicals
1997	*OECD*	Council Decision on the Adherence of non-member countries to the Council Acts related to the Mutual Acceptance of Data in the Assessment of Chemicals
1998	*OECD*	OECD countries agree on harmonized criteria for the classification of chemical substances
1998	*UNEP*	The Rotterdam Convention on the PIC Procedure for certain hazardous chemicals and pesticides in international trade was adopted
1998	*ICCA*	The International Council of Chemical Associations announced its initiative on high production volume chemicals
1998	*OECD*	Major International Conference on Pollutant Release and Transfer Registers (Tokyo, Japan)
2000	*UNEP*	Governments finalise POPs treaty

The basic direction that work on the "environmentally sound management of chemicals" should take was indicated in Chapter 19 of Agenda 21 from UNCED. Chapter 19 indicates six programme areas for future work:

a) Expanding and accelerating international assessment of chemical risks
b) Harmonization of classification and labelling of chemicals
c) Information exchange on toxic chemicals and chemical risks
d) Establishment of risk reduction programmes
e) Strengthening of national capabilities and capacities for management of chemicals
f) Prevention of illegal international traffic in toxic and dangerous chemicals

As a follow-up to UNCED, the Intergovernmental Forum on Chemical Safety (IFCS) was created by the International Conference on Chemical Safety held in Stockholm in April 1994 to integrate and consolidate national and international efforts to promote chemical safety. The Forum developed detailed recommendations at its first and second meetings. In addition, the intergovernmental organisations with substantial work programmes in the field of chemical safety created the Inter-Organisation programme for the sound Management of Chemicals (IOMC). The participating organisations are UNEP, ILO, FAO, WHO, UNIDO, UNITAR, and OECD. As with the IFCS, the IOMC does not have resources to implement recommendations made by countries and depends on governments to follow up by contributing to the various international programmes.

Another important achievement was the 1998 agreement by ministers and representatives from 57 countries on an International Legally Binding Instrument for the Application of the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (also known as the Rotterdam Convention on Hazardous Chemicals and Pesticides). The Convention requires that hazardous chemicals and pesticides that have been banned or severely restricted in at least two countries shall not be exported unless explicitly agreed by the importing country. The Convention will enter into force once it has been ratified by 50 countries. As of February 2001, there were 5 industrial chemicals and 26 pesticides (including 5 severely hazardous pesticide formulations) subject to the Interim PIC Procedure.

In addition, negotiations recently concluded on a global treaty on Persistent Organic Pollutants (POPs) to reduce the risks posed by 12 POPs, such as DDT and PCBs, to human health and the environment. Important other international achievements are a number of ILO Conventions and the FAO International Code of Conduct on the Distribution and Use of Pesticides. In recognition of the increasing role that non-OECD countries are playing in chemicals production, the OECD formally opened up its system for Mutual Acceptance of Data in the assessment of chemicals to non-member countries in 1997.

The OECD voluntary industry commitment made in 1995 by the major global producers of brominated flame retardants to take certain risk management actions on three types of flame retardants is an example of an international negotiated voluntary agreement. Unlike most such agreements, this one came about through negotiation with industry at the OECD level, rather than with national governments. An international accord for action *via* a negotiated agreement was possible since OECD governments all concurred that measures should be taken. However, attempts at the OECD to take concerted action to reduce risks from exposure to lead were not so successful since there was no consensus at the beginning of negotiations on the risks posed.

Working together in OECD has resulted in many savings for governments and industry. The Mutual Acceptance of Data system ensures that duplicative testing is avoided and that non-tariff barriers to trade are minimised. Sharing the burden on data gathering, testing and assessment of High Production Volume chemicals creates efficiencies for all involved. A study prepared by OECD (OECD, 1998a) which used data from governments and industry and conservative assumptions, indicates that the quantifiable net yearly saving for governments and industry of the chemicals programme is 324 million French francs (approximately US$ 46 million).

6. ECONOMIC AND ENVIRONMENTAL TRENDS AND POLICIES

The past and future trends in the chemicals industry that are key to any discussion on future policy options for the sound management of chemicals are summarised below.

Past and current trends	Projected future trends
Production, trade and structure of industry	
Total world production of chemicals has been growing rapidly.	*Total production will continue to grow at a faster rate than world population.*
Chemical companies in OECD countries continue to account for most of world chemical production and consumption, but non-OECD countries are closing the gap.	*Non-OECD countries will continue to close the gap in the production of chemicals.*
Chemicals are being produced in an ever growing number of countries.	*Investment in plants and equipment is expected to grow, with investment from OECD to non-OECD countries growing at the fastest rate.*
Companies in OECD countries are moving toward speciality, life science and high value-added products and away from basic chemicals. Such a shift will be accompanied by a greater reliance on innovative technology, R&D and a skilled work force.	*The trend will continue, with non-OECD countries increasing their share in basic chemicals production.*
Overall volume of trade is growing, with the fastest growth rate occurring in non-OECD countries.	*Overall volume of trade will continue to increase, with OECD regions having slight negative or slight positive inter-regional trade balances, but there will be significant negative inter-regional trade balances in non-OECD countries.*
There has been an increase in mergers and acquisitions as chemical companies consolidate to improve competitiveness and jettison low margin or cyclical businesses.	*There will be fewer but larger multinationals.*
Environmental trends	
Compared to other industries, the chemicals industry is a large user of water.	
Chemical companies in OECD countries are not a major emitter of CO_2, and their energy consumption and emissions have stabilised recently while production has gone up.	*As demand for chemicals increases, energy use will also increase as there is probably limited potential for further efficiency improvements in energy use. CO emissions from the global chemicals industry may increase, most significantly in non-OECD countries.*
The OECD chemicals industry is not a major contributor to tropospheric ozone and acid rain and, based on available data, emissions are in general going down.	
Companies in OECD countries have made tremendous progress in phasing out the production of CFCs.	*It is expected that production and consumption of ozone depleting substances will be phased out according to the agreed schedule in the Montreal Protocol.*

Based on *available data*, emissions of hazardous substances from chemical facilities in OECD countries are declining.	*It is projected that emissions of known hazardous substances, currently listed by governments, will decrease in OECD countries, but no projection is possible for non-OECD countries; nevertheless, the lack of data for chemicals on the market will continue to be a problem.*
For those countries with data, there has been a slight increase in the number of chemical accidents reported.	
Pesticide use/consumption is decreasing in a number of countries, but data are incomplete and do not necessarily reflect actual trends in risk. Efforts have been initiated in OECD countries to get better data.	*It is expected that, as alternatives are developed, pesticide use will continue to decrease.*
Environmental health and safety policies	
There has been a movement toward public right-to-know initiatives to increase public and worker participation in environmental decision-making.	*Public participation on environmental decision-making is expected to increase and consolidate.*
Eleven OECD countries have established PRTRs.	*Many more PRTRs are expected to be implemented in the coming years (both in OECD and non-OECD countries).*
Environmental monitoring has provided a considerable amount of data in the past; however, most of the monitoring has been conducted on just a few well known pollutants.	*It is anticipated that methodologies for environmental monitoring will be improved and that this will be increasingly used as a tool for exposure assessment.*
There has been an increasing use of government-industry partnerships to manage chemical risks.	*This trend is expected to continue.*
Each year, more companies are establishing environmental management systems (*e.g.* ISO 14001).	*This trend is expected to continue.*
There has been an agreement on a harmonized hazard classification system.	*Implementation of this (including agreement on labels) will be completed by 2008.*
Many resources have been spent on the regulation of new chemicals; industry is focusing more on safer new chemicals.	*It is expected that more resources will be spent on reducing the existing chemicals problem, possibly limiting resources spent on new chemicals.*
Economic instruments and socio-economic analysis to ensure cost-effective risk management approaches are being used more.	*There may be further application of the precautionary approach.*
The OECD programme to evaluate high production volume chemicals was introduced.	*The initial assessments of all HPV chemicals will be completed by 2020.*
New and innovative approaches to manage risks posed over the entire lifecycle of a product are being examined.	*More holistic approaches to chemical risk management (e.g. Integrated Product Policy) will be developed.*
Government/industry/academia partnerships to facilitate the development of more environmentally benign chemicals have been initiated.	*Partnerships for developing "sustainable chemicals" are expected to increase.*
An international framework to deal with global and regional risk assessment and management issues has been established.	*There will be a refinement of international co-operation with less overlap.*

7. KEY ISSUES AND FUTURE POLICY OPTIONS

This report has shown that the chemicals industry is undergoing a significant structural change in terms of the types of chemicals it produces, how and where. Chemicals remain a priority among environmental concerns for OECD countries, and managing chemicals in the face of incomplete information is the major challenge for the future. Governments are changing their policies to better allocate scarce resources to more effective approaches. This chapter identifies issues that both government and industry should consider in the management of chemicals, and suggests policy options for addressing them.

7.1 Key issues

In 20 years, the chemicals industry will be very different from the way it is now. First, global output will be 85% higher than it was in 1995 and non-OECD countries will contribute more to this production (31% in 2020 as compared to 21% in 1995 [Reference Scenario; Annex 6]).

In addition, the output in OECD countries will consist much more of speciality and life sciences chemicals, with non-OECD countries increasing in basic chemical production. This shift will result in a greater focus in OECD countries on the use of technology - both in the design and manufacture of chemicals - requiring a highly skilled and technically competent work force.

Finally, to respond to growing competitiveness in the industry (within and outside of OECD countries), profound changes in the composition and structure of the industry will occur. Most notably, by the year 2020 the chemicals industry will have fewer and larger multinational producers.

These changes may have the following implications for human health and the environment.

Greater production of chemicals in non-OECD countries

In the future, more products will be manufactured by the chemicals industry in non-OECD countries than today which could lead to a *shift in risk* from OECD to non-OECD countries. Today, the level of occupational and environmental protection in developing countries is lower than in OECD countries. If this does not change, risks linked to the production of chemicals could increase significantly. Benzidine dyes are a case in point. IARC classifies benzidine as a Group 1 carcinogen and benzidine-based dyes as a Group 2A carcinogen. OECD countries phased out the manufacture of these dyes in the 1970s and 1980s. However, during that same period, other countries *increased* production of these dyes to meet continuing demand (OECD, 1997a). This has also been the case with pesticides that are banned in OECD countries but are still being produced and used in non-OECD countries where workers are often less protected than in OECD countries.

Shifting production or use of certain chemicals to other countries could, in some cases, also *increase risk* in OECD countries. OECD countries may have strict limits on the amount of hazardous chemicals allowed in a product sold to consumers, but it is much easier to monitor these from the

domestic production *and* consumption side than solely from the importation side (as would be the case with chemical products imported by OECD countries). In some cases a pesticide, whose use is banned in an OECD country, is still made in that country but exported to a non-OECD country (under PIC procedures) where it is applied to fruits and vegetables which are exported back to the OECD country. Similarly, ceramic ware manufactured using lead-containing glazes and decorations is traded internationally in large volumes. Since many OECD countries have standards for leachability of lead from ceramics, but many non-OECD countries do not, concerns have been raised about the importation of these products as they can be imported in many sizes, shapes and batches which are difficult to monitor for leachability.

Not only could more imports of chemical products from non-OECD countries pose a problem to OECD countries, but an increase in the production volumes of chemicals at factories in non-OECD countries could also lead to higher risk. As has been found with certain persistent, bioaccumlative and toxic chemicals (*e.g.* POPs) and other substances (*e.g.* NOx, SOx), once they are released from facilities during manufacturing/processing or through their final use *(e.g.* pesticide application), these pollutants can travel long distances before they are finally deposited on land or reach the atmosphere of local communities. If non-OECD countries do not employ the same kinds of controls on emissions and use as OECD countries, it is possible that a shift in production to these countries could lead to greater emissions and subsequently to greater concentrations of these substances in the environment in both non-OECD and OECD countries.

OECD countries to concentrate on the production of life science and speciality chemicals

As chemical companies in OECD countries develop new and innovative products, the current chemical management paradigm may need to change. For instance, as more data are developed on basic chemicals that are produced in high volumes - and that will increasingly be produced in non-OECD countries - fewer resources may be available for generating data on the lower volume, speciality and life science chemicals whose numbers and volumes are expected to increase in OECD countries. Much will depend on whether these speciality or life science chemicals are considered to be existing - or new - substances. In contrast to existing substances for which little data are available on a per chemical basis, under current policies all new substances are subject to rigorous notification and data submission requirements.

Another question is whether the shift to these new "high tech" chemicals will require new skills for managing the risks they may pose. For instance, as the industry moves toward more biotechnology -related applications (for feedstocks, catalysts and final products), will regulatory authorities sufficiently understand the implications of using these new technologies as compared to using traditional chemicals? Also, is the current regulatory framework (*e.g.* legislation, regulations) flexible enough to handle these different kinds of substances?

Most important, will this shift to speciality and life science chemicals lead to better (*i.e.* more "sustainable") chemicals than those on the market today?

Fewer, but larger multinational companies

Along with increasing globalisation of the chemicals industry has come a greater commitment by the industry to continuously improve performance in the areas of health, safety and the environment, and to more openly communicate information and results. While not all chemicals industries in all countries subscribe to Responsible Care, efforts are underway to bring more

companies on board, and to improve the performance of those currently in the programme in terms of best practices, product stewardship, reporting of information/transparency, *etc*.

One of the benefits of a shift toward fewer, large multinationals could be faster and more coherent implementation of good environmental practices. It is anticipated that responsible chemical companies in OECD countries will follow the OECD *Guidelines for Multinational Enterprises* and use the same technologies and procedures in their facilities abroad as at home. Section V of the *Guidelines*, endorsed by OECD Member countries in 2000, states that enterprises are encouraged to adopt "technologies and operating procedures in all parts of the enterprise that reflect standards concerning environmental performance in the best performing part of the enterprise" (OECD, 2000a). Nevertheless, thought needs to be given to whether OECD should play an active role in promoting good corporate practices in non-OECD countries and, if so, what this role should be.

Even with a shift to larger companies in the chemicals industry, it is expected that there will still be many small and medium sized enterprises in OECD countries making and using chemicals and chemical products. What is the impact of these firms on chemical safety (relative to that of larger companies)? Do current reporting mechanisms take account of these impacts and, if not, is there a way to collect necessary information without imposing significant burdens on these companies?

Collecting and making relevant data more available

Over the past decade, either in response to government mandates or on the initiative of the chemicals industry, more environmental health and safety data on chemicals have been made available to government authorities.

This includes more information on releases of hazardous chemicals to the environment provided by PRTRs, more data on concentrations of chemicals in the environment *via* environmental monitoring, and more data on the hazards of chemicals obtained from laboratory testing data and models.

However, the objective is not merely to collect data, but rather to collect the *right* data. Emissions data by themselves cannot predict risk; hazard and exposure data are also needed. In light of the effort and expense involved in collecting test data (both in terms of resources and animal welfare), are the data being collected essential (*i.e.* for chemicals most likely to pose a risk)? With the shift toward more speciality and life science chemicals in OECD countries, will the approaches for collecting data used today (*e.g.* HPV chemicals) meet the needs of tomorrow? Should data on releases from chemical products throughout their lifecycle be collected and, if so, how can this be done in a cost-effective manner and without violating proprietary information such as product composition? Will a world where more information is available to more people (*i.e. via* the Internet) improve environmental performance everywhere?

Need for new and innovative policies

Over the last decade, virtually all OECD governments have attempted to undertake regulatory reforms to improve the effectiveness of their environmental programmes (OECD, 1997d). This trend is expected to continue as governments share experiences of what worked and what did not. The chemicals industry, too, has taken the initiative to develop new approaches to minimise risks while still ensuring the economic vitality of the industry. But, *changing* approaches does not necessarily translate into *better* approaches. To what extent are governments and industry measuring

the effectiveness of their actions against stated objectives? Do the benefits of such policies outweigh the costs? Are the tools for measuring effectiveness available and, if not, what should be done?

7.2 Policy options

The principal objective for the future is the best management of chemical risk at the least cost. If cost were *not* a factor, then the aim would be to collect the following information on all chemicals: hazard data, chemical release data (from production and products) and exposure data. With this information, releases from the production and use of hazardous chemical substances could be reduced, and these substances could be replaced with "sustainable chemicals". Since cost *is* a factor, the costs and benefits of policy options need to be considered carefully. The following paragraphs describe policies which have reduced the negative effects of chemicals on the environment and human health and *suggest* a range of options for the future. These options are *not* presented as recommendations, but merely aim to provoke discussion and examination of possible approaches that could lead to more effective management of chemicals. Obviously, each country's approach toward chemicals management should heed national priorities, policies and programmes, and take the form that is most appropriate for that country, whether they be voluntary, economic, or regulatory, or a combination of any of these.

Technological development and diffusion

During its development, the chemicals industry has become more and more sophisticated in its design and use of technology to reduce releases. Through the 1980s most of the effort was focused on the use of control technologies applied at the "end of the pipe" to minimise the amount of hazardous substances released to the environment. But, as the control technologies evolved, the cost of reducing the last remaining amounts of pollutants emitted grew at a much faster rate than the amount of emissions reduced. As a result, companies began to examine their entire production process to find more cost-effective ways to minimise the amount of substance that reaches the end of the pipe.

At the same time, governments began - and continue - to focus more on policies that prevent rather than control pollution. Pollution prevention options implemented by industry concentrate on source reduction, recycling, treatment and disposal. This can be accomplished in a number of ways, including in-process recycling, process controls, inventory controls, housekeeping changes, and sustainable chemistry.

One of the most promising new approaches used by the chemicals industry is to encourage "sustainable chemistry". Within the broad framework of sustainable development, efforts are being made to maximise resource efficiency through energy and non-renewable resource conservation, risk minimisation, pollution prevention, waste reduction at all stages of a product's lifecycle, and the development of products that are durable and can be reused and recycled. Sustainable chemistry strives to accomplish all this through the design, manufacture and use of efficient and effective, and more environmentally benign, chemical products and processes.

A company's decision to develop a "sustainable" chemical is principally driven by the need to make a new product that is cheaper than its alternative, or is more effective at a comparable cost. For instance, the current technologies for destroying hydrogen cyanide and/or ammonia in releases from chemical plants can require the use of expensive, complex or energy intensive processes, such as flaring or elaborate chemical treatment. Recent experiments have shown that it may be possible to

destroy these chemicals using a catalytic oxidation process at lower cost and using less energy (Benderly *et al.*, 1998).

Government "sustainable chemistry" programmes, in co-operation with the OECD, are identifying policies that can promote research and other work that will help companies to develop these new chemicals. They encourage sharing information on research and development and support teaching sustainable chemistry in academic institutions as part of the normal chemistry *curriculum*. However, unless the profile of sustainable chemistry is sufficiently raised within governments and industry, there may only be incremental improvements over time. When designing new chemicals, industry needs to include criteria that put the development of "sustainable" chemicals on an equal footing with low production costs and high product efficacy (see discussion on economic incentives below).

With the increasing reliance on computers, and the greater availability of laboratory test data on *some* chemicals, more researchers are developing models that can predict the effects *other* chemicals may have if man or the environment were exposed. Such models can reduce the need for animal testing, and generate more data faster than is possible today. The OECD is currently developing an inventory of existing models for review and consideration by governments, industry and academia. As a number of countries have collected considerable test data on new and existing substances, governments may wish to use these data more widely to compare results predicted by models with actual results found in laboratories, and possibly co-ordinate the results of this work to develop new models.

As chemicals production shifts to developing countries, efforts could be made to transfer to them non-confidential technologies that are currently used to minimise pollution in OECD countries. Much of the pollution control technology used in the basic chemicals industry is not proprietary. Therefore, to help ensure that indigenous chemical companies in developing countries are aware of the technologies and methods available for certain processes, and that they can use them, some international organisation (*e.g.* UNIDO) could serve as a clearing house for information on control technologies. Further, in the context of Responsible Care programmes, chemical companies from OECD countries with operations abroad should be encouraged to diffuse information on non-proprietary technology related to pollution control.

Legal and regulatory instruments

Production policy

Emissions from chemical production facilities of substances subject to reporting requirements have steadily declined in some countries over the last decade. Unfortunately, as not all countries have comprehensive reporting requirements - and those that do often do not have the same list of chemicals to be reported - it is not possible to determine whether releases of all known hazardous substances are declining. This situation should improve as more countries establish emission registers like PRTRs, a trend that should be encouraged. Emission registers not only help drive reductions in releases to air, water and soil, they also help identify trouble spots, set priorities for pollution prevention and play an essential role in monitoring whether targets and commitments to national and international agreements are being met. With this international dimension, compatible reporting mechanisms among countries make it possible to have global data that are comparable and make reporting easier for multinational companies. The OECD *PRTR Guidance Manual for Governments* (OECD, 1996a) was designed to help in this effort.

More and more chemical companies are publishing reports which document global emissions from all of their plants worldwide - although the results are not always broken down by country or region. This information is being posted on Web sites which allow a rough comparison. However, without the same standards being used by all companies, it is impossible to make meaningful comparisons. Agreed guidance in this area is necessary.

To obtain a better profile of polluting emissions, improvements in registers could be made in these three areas. They should:

- *be as comprehensive as possible in their coverage of the types of facilities that are required to report their releases*. The addition of seven new industries to the US TRI demonstrates how the picture of releases can change depending on which sectors are required to report (US EPA, 2000a). Many small and medium sized enterprises (SMEs) may be releasing large amounts of potentially hazardous pollutants, and the collection of data from SME operations could be important. However, care needs to be taken to balance the benefits of receiving reports from SMEs with the costs the SMEs and the authorities have to bear to do (and analyse) the reporting.

- *include data on diffuse emissions*, such as emissions from road traffic, households and land-use sources (*i.e.* agriculture), as is currently done in the Netherlands. This could help governments target policies toward the largest sources of emissions.

- *distinguish between safer and riskier chemicals*, data collected through emission registers are usually reported to the public in terms of amounts released. This does not distinguish between safer and riskier chemicals (*e.g.* the release of 100,000 tonnes of one chemical may pose a lower risk than the release of 10,000 tonnes of a more toxic chemical). This approach, therefore, is not always a good management tool, nor does it give a clear message to the public about potential risks. An approach should be developed to combine data on emissions with information on their potential human and environmental hazards. As mentioned in chapter 5, the US EPA and ICI have begun work to put total emissions into a simple relative-risk context. Another approach being developed for pesticides, is to combine data on emissions (*i.e.* pesticide applications) with data on hazard and exposure. The resulting "risk indicators" show relative risk trends over time for individual pesticides, groups of pesticides or total pesticide use nation-wide.

The OECD Pesticide Programme is carrying out a project to design models for calculating such indicators, focusing first on risks to the aquatic environment. The experience gained from such work should be shared with other governments and industry responsible for industrial chemicals. Governments and industry could work together, perhaps within the OECD Chemicals Programme, to help define the necessary variables for such systems and how they could be applied there.

While OECD governments have made good progress in establishing PRTR systems, such systems will also be important in the future in non-OECD countries. Under the auspices of the IOMC, guidance from OECD, UNEP Chemicals and UNITAR has been made available to developing countries. Although these organisations and experts from OECD countries have been active in providing technical and policy advice to countries considering establishing PRTRs, resources are still needed to establish emissions registers in non-OECD countries.

While information on the volumes of hazardous substances being *emitted* is of great importance in conducting risk assessments and considering risk management options, information on

actual *concentrations* in the environment is also important. To date, environmental monitoring systems have been designed to identify and measure the concentration of certain historical pollutants such as PCBs and DDTs. In the coming years, more toxicity data on high production volume existing industrial chemicals will be produced, and more hazard and risk assessments will be performed. In order to help this process, it would be beneficial to carry out "targeted environmental monitoring", which systematically provides monitoring data on chemicals of concern (*e.g.* chemicals with persistency, potential to bioaccumulate or high toxicity identified by performing hazard assessments). This and other monitoring data should be made widely available, perhaps *via* posting on the Internet.

In the meantime, efforts should be made to develop a method for directly evaluating hazard levels of environmental samples (*e.g.* surface water) without analysing each chemical in the sample one-by-one. As governments identify more chemicals they want to monitor in the environment, it will become increasingly difficult to identify and assess, in a comprehensive way, the adverse impacts in environmental compartments using conventional analytical methods. Applying bioassays to environmental samples - in which a number of individuals of a sensitive species are placed in water containing specific contaminants to determine the toxicity of the contaminants - could be one way to monitor overall hazard potential in the environment.

Products policy

In developing policies for the management of chemical products, there have been two fundamental questions that governments have had to address: (1) how much and what data on chemical hazards and exposure situations are needed to assess chemicals, and (2) how can such data be collected efficiently. Attempts to gather and assess the necessary information have been at the basis of all the regulatory frameworks for the management of chemical products regardless of the policy instruments used to get this information from the chemicals industry (legislative, voluntary and/or economic). The success (or lack thereof) has been due to a great extent to the size of the task at hand. For circumscribed groups, such as *new* industrial chemicals and pesticides, it has been possible to implement frameworks to ensure that sufficient information is collected and evaluated so that only those new products which pose a low health and environmental risk can enter the market.

Existing chemicals, as opposed to new chemicals, pose a particular risk management problem. One, the sheer number of all existing industrial chemicals dwarf the number of new chemicals that come on the market each year. Two, unlike new chemicals which are reviewed *before* they are marketed, existing chemicals are already on the market and thus any risk management decision affecting production or use could have a significant economic impact as capital has already been invested in plants and equipment, and workers are already employed. Three, while each government has some data on each new chemical that enters the marketplace, this is not the case with existing chemicals already in commerce. Various approaches to dealing with this huge group of chemicals have been attempted to date, but the question is whether these approaches have yielded the best results given the resources expended. Such questions have been raised of late with the recent concern about the concentrations in the environment of certain chemicals that are persistent, bioaccumulative and toxic, and which were not identified through the systematic review of existing chemicals, but rather through the identification of new endpoints of concern (*e.g.* endocrine disruption) and through monitoring activities which found high concentrations of specific chemicals in certain regions (*e.g.* POPs in the arctic region).

In addition, it has been questioned whether the systems in place to assure that new industrial chemicals are safe may take up more than their share of the resources available for chemicals management. This is particularly the case when one considers that, in some countries, some chemicals

which are notified never end up being marketed. Furthermore, new chemicals are usually initially produced in low volumes (when compared to chemicals already on the market), which only increase after a number of years. And, implicit in this approach is that industry will not add *any* new product to the market until sufficient information has been gathered and the chemical has been properly assessed. Therefore, efforts need to be made to find an equitable balance between the resources expended on new *versus* existing substances when considering their potential risk.

In response, the following policy options might be considered:

a. Inventory of chemicals on the market

As can be noted from earlier discussions in this report, there is no accurate account of the actual number of chemicals currently on the market in OECD countries. While estimates between 20,000 and 70,000 have been quoted, these numbers are generally based on inventories that were created in the late 1970s and early 1980s. Much has changed since then. Updating existing inventories - either with exact figures or with reliable estimates - to reflect the current situation of chemicals on the market (and their production volumes) could be a first step in implementing efficient programmes for their management. Not only would such inventories help provide the data necessary to set priorities for existing chemicals, they could also serve as the basis for determining whether a chemical is "new" or "existing". International co-operation in this area might help in streamlining the priority setting.

b. Generation and assessment of data

With the increasing effort being made by industry through voluntary commitments - if indeed work is carried out according to these commitments - basic health and environmental toxicity data should be available for close to three-fifths of the estimated 5,000 high volume chemicals produced in OECD countries by 2004. It is reasonable to expect that data and initial hazard assessments would be available for the remaining HPV chemicals by 2020, if not well before.

Progress towards meeting the 2004 targets has been slow to date due to start-up problems in both government and industry. Stronger policy instruments may be needed to ensure that the data are produced and the chemicals assessed. Regarding input from industry, for instance, if, after requesting data, none are received by a certain date on an existing chemical, further marketing of that chemical could be prohibited and only permitted after it has gone through a similar procedure as that applied for introducing new substances onto the market.

A scientific, rules-based approach has up to now been used in chemicals management. This requires however, that reliable information on effects from and exposure to chemicals is available as the basis for making risk management decisions. Where such information is not available more and more countries may take a precautionary approach.

Manufacturers and processors could be given greater responsibility to generate data, prepare draft assessment reports and provide this to governments, not only on HPV chemicals, but on other chemicals that meet certain criteria. Guidance could be provided by governments on data requirements, methodologies for assessing data and preparing reports, leaving the governments to conduct periodic audits to assure that companies are properly following their guidance.

Whatever instruments are put in place to ensure that the chemicals in commerce are safe, the question of how to set priorities for assessment remain. If there is a shift from production of basic,

high volume chemicals to lower volume, life sciences and speciality chemicals in OECD countries, selection criteria other than production/import volume might need to be considered.

Nor is it sufficient merely to assess the impact of an individual chemical at one point in its lifecycle. The regulatory reform movement of the last decade recognised that, in order for policies to be effective, governments need to take a more holistic view of the impacts of the chemicals industry, from the creation of a product to its final use and disposal. As described in Chapter 3, impacts can include the use of non-renewable resources as fuel and feedstocks, and the releases of climate change chemicals and other hazardous substances during manufacturing and use. The methodologies for conducting *lifecycle assessments* are still under development and would profit from collaboration among OECD countries. Such assessments should also consider the impacts of chemicals on the most sensitive groups of the population (*e.g.* children).

One of the data elements most lacking for lifecycle assessment is information on the use and release of hazardous substances from chemical products and preparations. Estimates can be made, but the further down the chain a product gets from the original point of manufacture, the less accurate the estimates become. Therefore, some governments have used product registers to provide a more complete picture on uses of hazardous substances (see Chapter 4). Data on uses of chemicals could be helpful to set priorities for assessing existing chemicals, for which different data sets could be required depending on use and probability of exposure to man and/or the environment (*e.g.* chemicals with "wide dispersive use by consumers" might require more data than chemicals produced and used by industry under strict controls). This would presumably lead to more focused and cost- effective use of government resources.

c. Risk management

As governments have gained experience in managing risks posed by chemicals, they are focusing more on anticipating problems rather than reacting to them. Further, they realise that it is not possible, nor prudent, to collect comprehensive toxicity and exposure data on all chemicals and to engage in resource intensive risk management oversight of each chemical. Many governments are leaning toward a system in which governments and industry share responsibilities, with involvement of NGOs.

Similar to the option discussed above for the provision and assessment of data, industry could, with proper guidance, be given a greater role in risk management. Rather than waiting until a government has assessed a chemical and determined its risk and necessary controls, industry could be more proactive by anticipating government concerns and acting accordingly. To facilitate this, and to ensure consistency across chemical types, governments could develop criteria for categorisation of chemicals according to "concern", as well as develop guidelines for actions industry should take depending on the category, especially for chemicals that fall within the "low concern" category. For these chemicals, governments would only need to periodically spot check compliance. For "high concern" chemicals (*e.g.*, persistent, bioaccumulative and toxic [PBT] chemicals), governments would need to continue to take the lead role. For "medium concern" chemicals, the responsibilities could be shared among the parties. If criteria for such categories can be defined, they could be applied equally to new and existing chemicals, which might eliminate the current "new chemical bias" discussed above. An added advantage of this approach is that it would help industry design new chemicals (or adapt existing ones) that better meet "low concern" criteria.

Under the current approaches used by governments to manage risk, the further a chemical substance works its way through the production/use phase (where it can be mixed with other substances to make new preparations and products) the less information on risks is available to the

users of the chemical products. While companies currently do provide warning labels on products or supply safety data sheets for those products that leave their facility, this is often only when required and for known hazardous substances at the first level of downstream use after they leave the production facility.

As mentioned in Chapter 5, the concept of integrated product policies (IPP) holds much promise. IPP should be based on lifecycle assessment and include stakeholder involvement during the process to develop that assessment. It should include the concept of shared responsibility throughout the chain of production/use (*i.e.* those involved in the production, consumption and disposal of a product). Governments could document and disseminate best practice guidelines, including descriptions of what has been successful. Before companies will embark on IPP, they will need some assurance that the approach they use will be acceptable to governments, that it will be consistently applied across the industry and be compatible with existing or planned legislation.

The movement toward a more "service-oriented" rather than "product-oriented" chemicals industry also could lead to better management of chemical risks. As this concept is new and not familiar to everyone, there may be some benefit to exchanging information on where and how chemicals management services have been applied and identifying techniques that have worked well. However, it must be recognised that some companies that provide such services may be reluctant to share details about their operations.

Changing the way products are used is also a new and innovative risk management approach. One example that is becoming increasingly widespread is the use of agricultural pesticides according to the principles of integrated pest management. "IPM" is an ecological approach that gives highest priority to the *prevention* of pest problems, thereby reducing the need for pesticides. This is done through (1) the optimal use of natural resources (*e.g.* maintaining healthy soil); (2) the elimination of all farm operations that have a negative impact on the agro-ecosystem (*e.g.* inappropriate or insufficient crop rotation); and (3) the protection and augmentation of natural enemies of crop pests. Next, IPM uses monitoring and forecasting to determine when pests have exceeded an "economic threshold". Finally, if pests exceed the threshold, pesticides may be used, with preference given to pesticides that will cause least harm to beneficial organisms and the agro-ecosystem. Thus, under IPM, pesticides are not the first recourse as a primary tool for pest control. They are used only when prevention has failed.

When considering the number of existing substances that are on the market, and how best to target for risk management those substances which are truly a problem, governments need to set priorities. Once a chemical of concern has been identified, one way of efficiently using government resources to identify possible risk management options is through a "cluster" approach which is an organising principle to collect and analyse information for the purpose of risk prioritisation and subsequent management. Under the traditional approach for managing chemical risk, a government evaluates *each of the uses* of a chemical across the industry sectors. With the cluster approach, chemicals related to *a particular use or process* (or other relevant grouping) are evaluated. The traditional approach requires a separate analysis of each industry associated with each major use. For the cluster approach, analysis can generally be focused on one industry and a specific use or process. The advantage of a cluster approach is that it improves the efficiency of the economic analysis because a single industry sector is analysed instead of several unrelated sectors. It also improves the efficiency of the exposure analysis because similar sets of exposure data need to be developed which tend to make the risk analysis more focused. And, by focusing on one industry sector, there is usually a smaller set of stakeholders. The use of a cluster approach does not obviate the need to do a risk assessment and the attendant socio-economic analysis on any substance and/or use for which risk management is necessary.

Identifying, examining, and acting on categories of chemicals of concern can also be an efficient way of managing risks. Based on available data and experience reviewing new chemical notifications on similar substances, the US EPA grouped chemical substances with similar physicochemical, structural, and toxicological properties into working categories (*e.g.* PBTs). Such groupings enable both new chemical notification submitters and EPA reviewers to benefit from the accumulated data and information on past decisions and facilitate the assessment of new chemical substances. Establishment of a PBT category alerts potential new chemical submitters to possible assessment or regulatory issues associated with the new chemicals review. It also provides a vehicle by which the agency may gauge the flow of PBT chemical substances through the New Chemical Programme and measure the results of its risk screening and risk management activities for PBT new chemical substances; as such, it is a major element in the agency's overall strategy to further reduce risks from PBT pollutants (US EPA, 1999).

Chemical accidents

While much work has been done to prevent chemical accidents, they still happen. Therefore it is still important to improve accident prevention policies as chemical accidents can lead to significant consequences for human health, the environment, and property. In addition, continued work on emergency preparedness and response helps ensure that appropriate infrastructures are available to enable the organisations involved in emergency response to act in the specific circumstances of chemical emergencies.

Real major chemical accidents fortunately do not happen often, but smaller accidents do occur more frequently. As a result, accident prevention tends to get less political priority when there are long periods without any major industrial accidents. The irony is that the success of prevention policies, which can be measured by the rarity of major accidents, leads to less attention being paid to successful programmes. Further development of effective methods for establishing the full economic consequences of chemical accidents would be very useful to ensure appropriate political support (*i.e.* by making these costs more transparent, governments could compare them with the cost of prevention and preparedness). Given that there are limited data on accidents, and the fact that they are very heterogeneous, it can be difficult to identify trends or learn from experience at the national level. That is why international co-operation is essential in this field. Continued work to collect and share internationally comparable data and to establish a common basis for the evaluation of the causes of accidents is critical for government and industry to find ways to prevent such accidents.

In order to facilitate and streamline international communication among authorities and industry about risk assessments and plant safety, it is essential to have a common understanding of terminology. The OECD Chemical Accidents Risk Assessment Thesaurus (CARAT), which is available on the Internet (http://www.oecd.org/EHS/CARAT/), is very useful in this respect but should be expanded.

The OECD *Guiding Principles on Chemical Accident Prevention, Preparedness and Response* have proven to be very useful for OECD and many non-OECD countries in the development of their chemical accident policies. For future work in this field, it would be helpful if this document, which was prepared in 1992, could be updated and expanded to include important new information that has become available over the last few years. However, certain information concerning the environmental impacts of chemical accidents and the long-term consequences of one-time releases is not available, which makes decision-making more difficult.

Another important element in good chemical accident prevention, preparedness and response is more and better implementation of these policies by small and medium sized enterprises, which may not always have the necessary information or means to carry this out. Under the concept of Responsible Care, larger companies might consider how they could assist smaller companies in this area.

Effective policies

As today, government regulators tomorrow will be faced with the question of how to make best use of their time and resources for developing policies to manage risks, and how they can design policies that will achieve the most benefit for the least cost.

Over the last ten years, many OECD countries have adopted requirements that new legislation and/or administrative regulations be subject to some form of socio-economic analysis in order to help determine whether a proposed regulation is necessary or burdensome. OECD has developed guidance on how such analysis can assist decision-makers, and also how governments can conduct "retrospective" studies to determine whether *ex post* impacts match the *ex ante* predictions made in the analysis. Governments should be encouraged to make use of such tools and to share information on their impact on policy. This would allow a comparison of the effectiveness of various risk management techniques within a country, and possibly across countries.

Economic instruments

Economic incentives, such as tax deductions for research and development associated with sustainable chemistry, or reduced notification fees (as well as expedited regulatory reviews) for new chemicals that are more "sustainable" than the substances they replace, could help promote the development of alternative chemicals which are environmentally friendly. Longer protection time for patent and proprietary rights for sustainable chemicals would also encourage the chemicals industry's research in this direction, although this might limit the diffusion of such technology.

Conversely, economic disincentives could be used to discourage the industry from marketing chemicals with unacceptable risks. The taxation of chemicals considered by governments to be of concern would provide an incentive for a company to decrease production of the taxed chemicals and shift to making alternatives that are not taxed. The resulting difference in price would encourage consumers to select cheaper alternatives that are more environmentally friendly. The example provided by the phase-out of leaded petrol is illustrative: in 20 OECD countries, a tax differential in favour of unleaded petrol was introduced at the same time as a series of other policy measures to encourage substitution of leaded with unleaded petrol (OECD, 1997b). While ideally the chemical taxes should be differentiated according to their environmental effects, a set tax or charge might also be levied on companies that produce chemicals for which sufficient data are not available in order to encourage further information gathering and research into these effects.

A chemicals policy simulation was undertaken by the OECD (see chapter 19, *OECD Environmental Outlook*, 2001a) to indicate the effects that might be expected from continued globalisation and trade liberalisation, and from attempts in OECD regions in coming decades to internalise the social and environmental effects of toxic chemicals in the environment. To represent the effects of further trade liberalisation, the simulation included the removal of all subsidies to the production and use of chemicals (including agrochemcials) in OECD regions, and the elimination of tariffs on imports of chemicals to OECD regions. Ideally, a tax or charge on the use of a limited

number of toxic chemicals that reflects their social and environmental costs would be levied. However, as the model used in the policy simulations does not distinguish between different types of chemicals, a tax was applied across all chemicals instead. Thus, the simulation included the application of an *ad valorem* tax which increases by 2 percentage points per year (*i.e.* reaching 50% of the pre-tax price of chemicals by 2020) on the use of all chemicals.

The results of the policy simulation show significant effects, with chemicals production in OECD regions estimated to be 20% lower in 2020 compared with the Reference Scenario, and about 12% lower worldwide (see Table 11). The environmental effects of the subsidy removal and tax implementation are even more substantial. Compared to the Reference Scenario, CO_2 emissions from the chemicals sector would be 24% lower in OECD regions in 2020. In non-OECD countries they would increase by just over 6% due to a "leakage" of chemicals production to these regions, but this would not offset the reductions in OECD regions. Thus, compared with the Reference Scenario, the chemicals industry would experience an overall reduction in CO_2 emissions of 6% worldwide in 2020 compared with the Reference Scenario as a result of these policies. In addition, SOx emissions from the chemicals industry would be reduced by 24% in OECD regions in 2020 compared with the Reference Scenario, while they would increase by 3% worldwide.[15] Water use by the industry would also decrease in OECD regions. Finally, as discussed in Chapter 7 of the *OECD Environmental Outlook* (OECD, 2001a), an *ad valorem* tax on chemical inputs would impact on the use of fertilisers in OECD agricultural production, with significant reductions in nitrogen loading to waterways from farm chemical run-off.

Another policy simulation that was undertaken for the *OECD Environmental Outlook* (see Chapter 12) involved the elimination of all subsidies to energy production and use in OECD countries, combined with an *ad valorem* tax on fossil fuel use which increases each year by 2 percentage points, 1.6 percentage points and 1.2 percentage points for coal, crude oil and natural gas respectively (*i.e.* by 2020 the tax rates would be equal to 50%, 40% and 30% respectively). It was found that while such a policy would lead to only a very small decrease in chemicals production both in OECD regions and worldwide to 2020, there would be a significant reduction in energy-related emissions from the chemicals industry in OECD countries, particularly in SOx emissions (Table 11).

15. This assumes that the increased transfer of chemicals production to non-OECD regions would not result in any additional increases in process efficiency or increased uptake of emissions reduction technologies.

Table 11
Effects of subsidy and tax policy shock runs on the chemicals industry and its environmental impacts

(% change from Reference Scenario in 2020)

Effects		Policy simulations	
		Chemicals industry subsidy removal and tax on all chemicals use	Energy subsidy removal and tax on all energy use
Gross production	OECD	-20%	-1%
	World	-12%	-1%
CO2 emissions	OECD	-24%	-7%
	World	-6%	-3%
SOx emissions	OECD	-24%	-45%
	World	+3%	-4%
Water use	OECD	-23%	-1%
	-	-	-

Note: The energy subsidy and tax policy simulation was applied to all energy-using sectors, not just the chemicals sector. See OECD Environmental Outlook, (OECD, 2001a); Chapter 12, for more details.
Source: Reference Scenario and Policy Simulations.

Voluntary agreements

Further progress can be made in chemicals management through formalised industry initiatives and bilateral agreements between industry and government. One of the major voluntary efforts of the chemicals industry over the last decade has been the development and implementation of Responsible Care. Industry has taken greater responsibility for the management of chemicals, and has made an effort to do so in a transparent way. But, as each national industry has its own set of guiding principles that define its approach to Responsible Care - and some are more ambitious than others - a key challenge to industry will be to develop performance measures which can show stakeholders that progress is being made.

With the shift toward greater production of chemicals in non-OECD countries, industry should be encouraged to implement effective Responsible Care programmes wherever they operate. If Responsible Care really works, then the environmental performance of companies operating in non-OECD countries where strong chemicals regulations do not currently exist, should improve. Following OECD's recent *Guidelines for Multinational Enterprises* will be a step forward. To show progress, companies should be encouraged to develop corporate-wide environmental reporting procedures and documents.

The concern associated with increasing production and consumption of chemicals in developing countries is linked to the extent to which these countries have, or plan to establish, chemicals management systems. Since regulations can take considerable time to implement, voluntary approaches might be the best route to follow, at least in the short term.

The movement by the chemicals industry toward the adoption of environmental management systems based on ISO 14001 should be encouraged. While such systems do not in and of themselves result in better environmental performance, they do provide a framework for better practices and reporting that help build an infrastructure for the better management of chemicals.

Information and other instruments

Recently, the term "environmental democracy" has crept into the environmental management lexicon. It is a recognition that all those affected by environmental decisions, not just governments and industry, need to be informed of relevant issues and be invited to participate in the decision-making process. This includes, for example, empowering local communities near chemical plants, trade unions and public interest groups so that they can play a more active role in environmental issues that affect them. Access to, and understanding of, environmental information is critical for effective stakeholder participation. Right-to-know initiatives in OECD countries, for example, and the development of PRTR systems with a wide dissemination of data have facilitated this participation, but more can still be done.

First, adding more environmental information to the public domain does not necessarily lead to better stakeholder involvement. Such information must be presented in a way that is useful to everyone, and it must be put in a proper context. Governments, industry and NGOs need to improve their efforts to communicate risk information effectively and provide, if necessary, environmental education and training to stakeholders.

Second, in some cases stakeholders who are affected by, and have an interest in, a risk management decision cannot take part in it due to limited resources. If this participation is useful to the decision-making process, then governments and industry might consider providing financial support to make such involvement possible. It is in the interest of everyone to have a transparent decision-making process with fair and active participation by all affected parties that can produce decisions that will be widely supported and effectively implemented.

International action

While good progress has been made in addressing a number of issues identified at the UNCED in 1992, the priorities for international action, described in Chapter 19 of Agenda 21, still hold. Some specific highlights, which were reinforced by the IFCS Forum III (15-20 October 2000; Bahia, Brazil) adoption of Priorities for Action beyond 2000 (see Annex 23), include:

- accelerate the testing and assessment of High Production Volume chemicals based on the principle of burden sharing;

- finalise the development of harmonised classification criteria and start the implementation of a harmonised classification and labelling system;

- improve information generation and systems for information exchange and make information widely available to the public, particularly through electronic means, so that chemical safety can be addressed in a more equitable way by all stakeholders – an important element of this is a PRTR;

- manage the risks posed by the stock of obsolete chemicals;

- investigate and ensure that the structure for global chemical safety management can respond adequately to any negative implications of the changing structure and increasing globalisation of the chemicals industry;

- ensure that those countries which consider chemical safety a national priority and do not yet have the appropriate infrastructure get co-ordinated and structured capacity-building assistance; and

- ensure adequate monitoring and enforcement of international agreements.

8. CONCLUSIONS: ACHIEVEMENTS AND FUTURE CHALLENGES

This report has shown that over the last three decades there has been considerable improvement in managing chemical safety and even more progress is expected in the next two decades. Yet, despite these achievements, it is generally recognised that even today the lack of data on the uses, and health and environmental effects, of chemical substances and the products developed from them is a major handicap. Only when such information is available will it be possible to properly evaluate the consequences of the use of chemicals and ensure that the most effective chemical safety policies are in place. Until then, chemical safety will remain an area of environmental policy that will require priority attention.

8.1 Highlights of the past

Over the last three decades many essential elements of effective chemical safety policy have been developed by countries and through international co-operation. Highlights of progress made include:

- substantially reducing emissions of many hazardous chemicals and reducing energy use in production;
- designing systems and operations that ensure safety in plants during the production of chemicals;
- identification of information needs for different types and quantities of chemicals to allow appropriate screening and full assessments;
- minimising the introduction of unsafe new chemicals onto the market;
- development of safety testing methods, a procedure for quality control of such testing, and a system to avoid duplicative testing and the introduction of non tariff barriers to trade due to different safety testing systems (*i.e.* MAD);
- development of methods to assess effects of chemicals on human health and aquatic species, and to assess human and environmental exposure;
- development of an array of risk management methods which are often used in a combination;
- realisation by the chemicals industry that the safety of the chemicals they produce is part of their responsibility (*i.e.* Responsible Care has spread to 46 countries);

- establishment of an extensive international framework (IFCS, IOMC) and adoption of instruments to ensure well co-ordinated global chemicals control (*e.g,* conventions on PIC, POPs, ozone layer protection); and

- a good start with the implementation of Agenda 21, Chapter 19.

8.2 Building on past achievements

Many of the achievements mentioned above will require further attention in order to ensure progress. For other, perhaps *more difficult* issues work has begun on finding ways to address them properly, but additional efforts are needed. These include:

- improving the efficiency of, and setting priorities within, the chemicals control system;

- testing, assessment and management of the safety of existing chemicals;

- developing better assessment methods, especially with respect to ecosystems effects and cumulative effects, and developing the ability to evaluate the safety of chemicals produced through modern technology;

- developing better exposure models and scenarios;

- making effective use of socio-economic analyses in risk management;

- ensuring good compliance with voluntary agreements; and

- developing risk management methods that can lead to faster results while remaining based on sound science.

8.3 New approaches for the future

Considering the main outcomes of this *Outlook*, three main groups of issues - in addition to those mentioned above - will deserve more attention in the future:

- creating a holistic approach to chemical safety that not only addresses the risks to man and the environment resulting from the production of individual substances, but also the risks posed by products made from these substances and by the use of natural resources and energy to create these substances and products;

- examining and responding to the possible negative impacts on chemical safety resulting from the increasing globalisation of the chemicals industry; and

- facilitating and promoting environmental democracy in relation to chemical safety, so that all stakeholders will be better informed and on an equal footing when discussing relevant environmental issues.

These three aspects are addressed in more detail below.

Holistic chemical safety approach

Developing such an approach means:

- improving the knowledge base for the design of safe chemicals (building on current sustainable chemistry efforts);

- finding ways to better evaluate and manage the risks resulting from the release of chemicals from products; this will involve further developing lifecycle assessment techniques and paying more attention to the risks for specific, sensitive groups of the population (such as children) or for sensitive ecosystems;

- finding the right means to balance the efficacy of products with their overall "environmental and health performance" (including resource use, safety during production and releases from product use) which will require an Integrated Product Policy;

- effective implementation of an Extended Producer Responsibility regime to ensure that industry takes the Responsible Care concept a step further; this would also mean that large multinational companies which apply Responsible Care will make efforts to assist small- and medium sized enterprises in implementing more comprehensive pollution prevention, resource efficiency and safety policies; and

- further developing and extending the concept of the chemicals industry as a "service industry"; as these chemical "service" companies focus on providing a *function* for their customers rather than a *product*, they have more opportunities to reduce risks at the production, use and waste disposal stage; chemicals users and governments could work together to develop, apply and propagate this concept.

Managing the safety aspects of globalisation in the chemicals industry

This will involve:

- supporting the development of the chemical safety regimes in non-OECD countries. One way of doing this would be to involve them more closely in OECD work; and

- finding ways to respond to potential negative impacts on the environment due to the fast pace of restructuring and reorganisation in multinational enterprises. If national structures cannot adequately deal with this, closer international co-operation might be needed to develop efficient and fast international information exchange and control systems.

Environmental democracy in chemical safety

Governments and industry have to work closely together to ensure chemical safety, and trade unions, the public and workers must play an active role in the decision-making process so that there will be greater transparency, and better and fairer policies can be implemented. This will call for:

- information on releases (*e.g.* PRTRs) and the safety of chemicals needs to be made widely available; public right-to-know should be strengthened as much as possible and yet be compatible with justified business interests;

- information should be made available in a way that will make it possible for public interest groups and the public to understand the implications of the information in terms of risks to human health and the environment; and

- efforts should be made to educate the public about chemical safety and, where necessary, to provide public interest groups with resources so that they can play an equitable role in policy discussions related to chemical safety.

ANNEXES

ANNEX 1: Definitions of the "chemicals industry"

Breakdown by sector according to different sources

CMA & US EPA[16]	CEFIC	CIA[17]	IEA[18]	OECD Reference Scenario
• Chemicals and allied products • Industrial organic chemicals • Plastics materials and synthetics • Pharmaceuticals • Soaps, cleaners and toilet goods • Paints and allied products • Industrial organic chemicals • Agricultural chemicals (incl. fertilisers and pesticides) • Miscellaneous chemical products	• Petrochemicals and derivatives • Plastics and polymer-related products • Inorganic chemicals • Specialties, performance and consumer oriented products, including adhesives and paints • Surfactants, oleochemistry and related products • Agriculture, food chain and protection products (includes biocides)	Manufacture of industrial chemicals • Basic industrial chemicals, except fertilisers • Fertilisers and pesticides • Synthetic resins, plastic materials and man-made fibres except glass Manufacture of other chemical products • Paints, varnishes and lacquers • Drugs and medicines • Soap and cleaning preparations, perfumes, cosmetics and other toilet preparations • Chemical products not elsewhere specified	Manufacture of • Basic chemicals, *e.g.* industrial gases, inorganic acids, alkalis, basic organic chemicals • Fertilisers and nitrogen compounds • Plastics in primary forms and of synthetic rubber • Manufacture of other chemical products • Pesticides and other agro-chemical products • Paints, varnishes and similar coatings, printing ink and mastics • Pharmaceuticals, medicinal chemicals and botanical products • Soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations • Other, *e.g.* explosives, gelatin and its derivatives, peptones, essential oils, materials used in textile finishing	• Manufacture of basic chemicals, except fertilisers and nitrogen compounds • Manufacture of fertilisers and nitrogen compounds • Manufacture of plastics in primary forms and of synthetic rubber • Manufacture of pesticides and other agro-chemical products • Manufacture of paints, varnishes and similar coatings, printing ink and mastics • Manufacture of pharmaceuticals, medicinal chemicals and botanic products • Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations • Manufacture of other chemical products *n.e.c*. • Manufacture of man-made fibres • Manufacture of rubber tyres; retreading and rebuilding of rubber tyres • Manufacture of other rubber products • Manufacture of plastic products

CMA: US Chemical Manufacturers Association/ **US EPA**: US Environmental Protection Agency/ **IEA**: International Energy Agency/**CEFIC**: European Chemical Industry Council/ **CIA**: UK Chemical Industries Association

16. CMA and US EPA cover the chemicals industry as US Standard Industrial Classification (SIC) 28.

17. The UK Chemicals Industry Association chemicals data covers the chemicals industry defined within codes 351 and 352 of the United Nations International Standard Industrial Classification (ISIC) (second revision).

18. For the IEA data, the chemicals industry corresponds to Division 24 of ISIC Revision 3, *i.e.* Manufacture of Chemicals and Chemical Products.

ANNEX 2: World chemicals industry output 1970-98

(*Source:* CMA, 1999a)

	Output (billion US dollars)			
	1970	**1980**	**1990**	**1998**
Total World Output	171.3	712.6	1232.1	1503.2
US	49.2	168.3	293.0	391.7
Canada	2.5	9.6	19.8	20.7
Mexico	2.1	10.6	13.5	14.5
NAFTA	53.8	188.5	326.3	426.8
Belgium/Luxembourg	1.7	16.6	28.1	36.2
France	7.2	37.7	66.1	79.7
Germany	13.6	59.3	100.5	106.5
Italy	5.9	28.7	52.0	49.8
Netherlands	2.4	14.3	25.7	29.2
Spain	n/a	14.1	27.9	29.3
Sweden	n/a	4.8	8.1	9.4
Switzerland	n/a	7.1	15.4	24.6
UK	7.6	29.5	44.5	52.7
Other	n/a	15.1	28.9	37.1
Western Europe	47.0	227.1	397.1	454.5
Poland	n/a	n/a	3.9	6.4
Russia	n/a	n/a	62.3	23.8
Other	n/a	n/a	36.3	20.9
Central and Eastern Europe	24.5	101.8	102.5	51.0
Japan	15.3	79.2	162.3	177.3
Korea	0.4	6.1	22.1	44.7
JPK	15.7	85.3	184.4	222.0
Australia	1.5	5.7	9.5	13.4
China	10.3	23.9	44.3	84.8
Malaysia	0.1	0.6	2.5	7.2
Singapore	0.1	0.4	2.7	4.9
Taiwan	0.5	5.7	17.8	28.1
Thailand	0.1	0.8	4.5	4.8
Other Asia/Pacific	2.7	7.6	15.6	26.9
EAS less China	3.5	15.1	43.1	71.9
Argentina	n/a	n/a	8.6	10.4
Brazil	n/a	n/a	32.7	39.5
Other	n/a	n/a	22.7	42.2
Latin America	9.8	34.2	63.9	92.1
Africa	2.3	14.4	24.0	30.6
Middle East	1.0	6.3	18.1	26.6
India	1.9	10.3	18.9	29.5
Rest of World	4.2	31.0	61.0	86.7

ANNEX 3: Chemical sector output estimates (% share for available regions)

(*Source:* CIA, 1999)

% Share of sector output for available regions[19] (1996)

	Basic industrial chemicals	Fertilisers and pesticides	Plastics, rubber and man-made fibres	Paints and varnishes	Pharma-ceuticals	Soaps and toiletries	Other chemicals
Western Europe	33	27	33	42	37	39	31
US & Canada	31	25	27	24	29	26	34
Australia/NZ	1	2	1	2	1	1	2
Japan	14	8	19	16	17	16	18
China	8	14	3	2	5	4	4
Other Far East	8	8	11	8	4	6	6
Indian Sub-cont.	1	8	2	2	2	1	2
Central and Southern America	4	8	4	5	5	7	3
Sector total for available regions in billion US dollars	360	90	235	79	305	160	131
(% total chemicals)	(26)	(7)	(17)	(6)	(22)	(12)	(10)

19. Sector data are not available for all regions, although the CIA analysis covers some 93% of world chemical sales in 1996.

ANNEX 4: Chemicals output, demand, and trade growth between 1979-96, and demand per capita in 1996

(*Source:* CIA, 1999)

	Growth between 1979-96 (real terms, % p.a.)				Demand per capita in 1996 US dollars (rank order)	
	Output	**Exports**	**Imports**	**Home demand**		
Western Europe	2.6	5.5	4.0	2.2	1,073	(3)
US & Canada	2.0	4.0	8.5	2.2	1,295	(2)
Australia/NZ	1.7	6.0	2.8	1.6	900	(4)
Far East	6.1	10.9	9.5	6.1		
Japan	3.8	6.7	5.8	3.6	1,620	(1)
China	11.1	19.0	16.7	11.5	72	(9)
Other Far East	9.6	16.0	9.6	8.4	297	(5)
Indian Sub-continent	7.4	17.2	9.3	7.4	29	(11)
Middle East	7.9	13.1	7.2	6.9	181	(7)
Africa	2.5	7.3	1.9	1.6	40	(10)
Central and Southern America	2.3	10.7	5.8	2.7	192	(6)
Central and Eastern Europe	-2.5	5.4	5.4	-2.1	159	(8)
World total	2.6	6.7	6.7	2.6	262	

Note: In the CIA regions, (1) Central and South America includes Mexico, and (2) Central and Eastern Europe includes the former USSR.

ANNEX 5: World exports/imports from 1980 to 1998

(*Source:* CMA, 1999a)

Billion US$	Exports		Imports	
	1980	**1998**	**1980**	**1998**
NAFTA	25.2	80.4	12.7	77.4
Western Europe	96.7	319.9	77.3	255.7
Central and Eastern Europe	3.5	13.6	5.8	18.2
Japan, Korea and Australia	8.1	40.8	11.5	42.3
Middle East	1.1	8.3	4.7	15.5
Latin America	2.8	9.3	8.8	24.9
China	1.1	14.3	2.9	21.3
Rest of World	4.3	23.9	19.1	55.2
OECD	133.5	454.7	107.3	393.6
Non-OECD	9.3	55.8	35.5	116.9

ANNEX 6: Projection for growth in GDP, population and chemicals industry production from 1995 to 2020

(*Source:* OECD Reference Scenario)

Regions[20]	1995	2000	2005	2010	2015	2020
Real GDP (million 1995 US$)						
NFT	7,347,191	8,476,142	9,589,976	10,588,109	11,462,700	12,409,534
WEU	8,070,566	9,086,650	10,330,958	11,129,375	11,813,358	12,539,376
CEU	449,128	536,005	667,960	816,590	974,547	1,163,059
JPK	5,083,701	5,277,221	5,941,622	6,527,937	6,997,868	7,538,691
ANZ	372,382	431,693	502,884	560,690	611,497	666,909
FSU	447,180	394,008	467,958	583,161	709,505	863,221
CHN	652,966	941,786	1,236,721	1,578,404	1,995,375	2,522,499
EAS	783,783	882,461	1,115,584	1,410,290	1,757,478	2,158,880
SOA	358,538	466,378	578,416	710,524	872,805	1,072,151
MEA	463,301	511,522	570,320	635,877	708,969	790,464
LAT	1,251,984	1,365,434	1,590,612	1,835,021	2,106,719	2,418,645
ARW	646,118	739,982	866,203	1,004,166	1,164,104	1,349,515
OECD	21,322,968	23,807,710	27,033,401	29,622,701	31,859,971	34,317,569
Non-OECD	4,603,870	5,301,571	6,425,813	7,757,443	9,314,956	11,175,376
World	25,926,838	29,109,281	33,459,213	37,380,145	41,174,926	45,492,945
Population (million persons)						
NFT	391	411	430	448	466	482
WEU	385	389	391	391	389	387
CEU	158	163	167	171	175	178
JPK	170	173	176	177	177	175
ANZ	21	23	24	25	26	27
FSU	293	293	293	295	296	296
CHN	1,226	1,283	1,335	1,382	1,424	1,460
EAS	443	477	509	540	571	600
SOA	1,225	1,339	1,450	1,554	1,650	1,742
MEA	158	179	198	221	245	269
LAT	380	411	441	470	499	527
ARW	855	958	1,068	1,179	1,295	1,416
OECD	1,126	1,159	1,188	1,211	1,232	1,248
Non-OECD	4,580	4,940	5,294	5,641	5,980	6,311
World	5,706	6,099	6,481	6,853	7,212	7,559

20. NFT-NAFTA (US, Canada, Mexico); WEU-Western Europe; CEU-Central and Eastern Europe; JPK-Japan and Korea; ANZ-Australia and New Zealand; FSU-Former Soviet Union; CHN-China; EAS-East Asia; SOA-South Asia MEA-Middle East; LAT-Latin America; ARW- Africa and Rest of World.

ANNEX 6 (cont.)

Chemicals manufacturing industry production (million 1995 US$)

	1995	2000	2005	2010	2015	2020
NFT	578,167	670,120	760,009	841,917	914,250	993,157
WEU	812,148	910,325	1,033,746	1,111,874	1,179,360	1,252,188
CEU	50,067	61,074	78,744	99,712	122,617	150,586
JPK	638,687	659,445	741,762	816,484	878,100	950,262
ANZ	23,882	27,866	32,410	35,932	38,866	41,973
FSU	40,547	37,122	44,510	56,116	69,393	85,796
CHN	122,546	184,595	245,173	315,037	400,370	507,089
EAS	88,609	100,100	131,568	174,574	228,329	293,004
SOA	32,395	43,018	53,401	66,081	82,284	102,702
MEA	37,757	44,204	51,462	60,146	70,083	80,963
LAT	161,704	174,010	203,023	235,207	271,458	313,361
ARW	68,652	78,687	922,08	107,307	124,928	145,189
OECD	2,102,953	2,328,832	2,646,672	2,905,921	3,133,195	3,388,168
Non-OECD	552,214	661,739	821,348	1,014,471	1,246,848	1,528,107
World	2,655,168	2,990,571	3,468,020	3,920,392	4,380,043	4,916,275

ANNEX 7:
World chemical demand from 1995 to 2020

(*Source:* OECD Reference Scenario)

(million 1995 US$)

Regions[21]	1995	2000	2005	2010	2015	2020
NFT	578,697	668,696	758,291	839,602	911,661	990,226
WEU	789,084	886,411	1,008,524	1,088,298	1,158,055	1,233,303
CEU	60,480	72,561	91,436	112,810	135,687	163,179
JPK	632,368	655,745	738,863	814,009	876,072	948,280
ANZ	29,033	33,481	38,824	43,139	46,920	51,043
FSU	36,430	32,712	39,173	49,239	60,544	74,454
CHN	142,508	206,434	271,083	345,756	436,503	549,995
EAS	109,245	122,067	154,835	197,031	247,468	306,533
SOA	44,631	57,245	70,241	85,676	104,849	128,565
MEA	38,504	43,656	49,861	56,775	64,482	73,031
LAT	180,524	195,005	226,770	261,297	299,780	344,199
ARW	82,386	93,982	109,979	127,149	146,894	169,709
OECD	2,089,664	2,316,895	2,635,941	2,897,860	3,128,396	3,386,034
Non-OECD	634,230	751,104	921,944	1,122,926	1,360,522	1,646,489
World	2,723,894	3,067,999	3,557,885	4,020,786	4,488,918	5,032,523

21. NFT--NAFTA (US, Canada, Mexico); WEU--Western Europe; CEU--Central and Eastern Europe; JPK--Japan and Korea; ANZ--Australia and New Zealand; FSU--Former Soviet Union; CHN--China; EAS--East Asia; SOA--South Asia; MEA--Middle East; LAT--Latin America; ARW- Africa and Rest of World

ANNEX 8:
Yearly growth rates (%) in production capacity for petrochemicals and plastics

(*Source:* European Chemical News, 1999)

	Petrochemicals		Plastics	
	1990-2000	**2000-2010**	**1990-2000**	**2000-2010**
Western Europe	4.2	1.4	2.3	2.0
Russia	0.3	3.9	1.7	3.5
Other E. Europe	-0.5	2.3	0.5	3.9
Africa	12.4	5.8	5.6	5.0
Middle East	19.8	4.5	10.0	3.8
China	16.1	6.9	8.8	5.6
India	33.8	5.4	20.8	5.3
Japan	2.1	2.4	1.5	1.9
Pacific Rim	20.2	5.2	10.0	5.1
Other Asia	7.1	3.9	2.7	3.7
US/Canada	4.5	2.8	2.7	2.6
Latin America	9.0	7.1	3.9	5.1

ANNEX 9:
World exports/imports (1995, 2010, 2020)

(Refers only to inter–regional trade)

(*Source*: OECD Reference Scenario)

million 1995 US$	IMPORTS			EXPORTS		
	1995	2010	2020	1995	2010	2020
Regions[22]						
NFT	90,185	132,332	160,425	89,656	134,618	163,226
WEU	292,628	413,569	479,647	315,692	437,126	498,439
CEU	22,478	35,984	46,202	12,066	22,871	33,554
JPK	43,022	64,652	80,212	49,341	67,072	81,980
ANZ	10,273	15,182	18,627	5,122	7,972	9,548
FSU	6,093	8,612	11,687	10,210	15,456	23,005
CHN	37,356	69,732	101,974	17,394	38,828	58,464
EAS	53,633	87,857	121,968	32,998	65,400	108,438
SOA	15,780	26,541	36,445	3,544	6,944	10,573
MEA	12,433	16,841	20,136	11,686	20,174	27,969
LAT	32,809	47,035	58,746	13,990	20,942	27,902
ARW	22,197	33,319	42,619	8,462	13,477	18,098
World	638,892	951,661	1,178,692	570,165	850,884	1,061,203
OECD	458,589	661,720	785,113	471,878	669,661	786,749
Non-OECD	180,303	289,941	393,578	98,287	181,223	274,452

22. NFT-NAFTA (US, Canada, Mexico); WEU-Western Europe; CEU-Central and Eastern Europe; JPK-Japan and Korea; ANZ-Australia and New Zealand; FSU-Former Soviet Union; CHN-China; EAS-East Asia; SOA-South Asia; MEA-Middle East; LAT-Latin America; ARW- Africa and Rest of World.

ANNEX 10:
Agro chemicals industry consolidation from 1983 to 1999

(*Source:* Johnen, B; Zeneca; Personal Communication)

1983 Companies	1999 Companies
Ciba	Novartis
Dr Maag	
Sandoz	
Diamond Shamrock	
Velsicol	
Bayer	Bayer
Monsanto	Monsanto
DuPont	DuPont
Shell*	AHP
Celamerck	
Cyanamid	
Zeneca	Zeneca
Stauffer	
ISK	
Fermenta	
Rhone-Poulenc	Aventis
Union Carbide	
Hoechst	
Schering	
FBC	
Dow	Dow AgroSciences
Eli Lily	
BASF	BASF
Sumitomo	Sumitomo
Chevron	
Rohm & Haas	Rohm & Haas
FMC	FMC

* Shell US acquired by DuPont

ANNEX 11:
1995 Industrial water use

(*Source:* Polestar)

Industry water use in million cubic metres

Regions[23]	TOTAL	Chemicals	Iron + steel	Light industry	Non-ferr. metals	Other	Paper + pulp	Stone, glass, clay	Transport equip.
NFT	41,027	18,322	8,714	2,163	958	2,328	5,524	274	2,745
WEU	29,119	13,271	7,086	1,591	505	1,249	3,224	106	2,087
CEU	7,462	2,477	2,671	638	213	526	447	101	388
JPK	13,327	4,811	5,411	453	235	554	1,098	55	712
ANZ	2,385	801	673	155	126	194	275	77	84
FSU	341	65	140	13	19	60	27	4	14
CHN	856	250	417	21	17	54	39	9	48
EAS	1,102	442	330	71	19	76	72	19	74
SOA	216	63	93	8	2	18	8	8	15
MEA	171	55	34	9	3	50	11	5	5
LAT	2,225	937	624	162	67	133	171	30	99
ARW	238	82	76	14	6	28	16	6	10
OECD	93,321	39,682	24,555	4,999	2,037	4,851	10,566	614	6,017
Non-OECD	5,148	1,894	1,714	298	134	419	343	82	265
World	98,469	41,576	26,269	5,297	2,170	5,270	10,910	696	6,281
% of total									
OECD	100%	43%	26%	5%	2%	5%	11%	1%	6%
Non-OECD	100%	37%	33%	6%	3%	8%	7%	2%	5%
World	100%	42%	27%	5%	2%	5%	11%	1%	6%

23. NFT-NAFTA (US, Canada, Mexico); WEU-Western Europe; CEU-Central and Eastern Europe; JPK-Japan and Korea; ANZ-Australia and New Zealand; FSU-Former Soviet Union; CHN-China; EAS-East Asia; SOA-South Asia; MEA-Middle East; LAT-Latin America; ARW- Africa and Rest of World.

ANNEX 12:
1995 Chemicals industry process fuel use

(*Source:* Polestar)

In Peta Joules

Regions[24]	TOTAL	Biomass	Coal	Crude Oil	Electricity	Heat	Nat Gas	Petroleum
NFT	7,319.690	-	250.950	-	982.180	135.440	3,042.370	2,908.740
WEU	4,431.240	21.810	85.680	0.590	628.480	27.000	1,124.720	2,542.960
CEU	997.140	16.300	80.270	-	89.470	99.190	415.780	296.140
JPK	2,592.920	0.920	17.780	99.730	305.510	-	42.940	2,126.040
ANZ	184.780	7.590	6.150	-	20.140	-	100.050	50.860
FSU	2,166.210	36.380	12.180	30.100	228.180	774.640	841.040	243.670
CHN	4,178.030	-	2,189.770	16.870	487.340	264.730	267.460	951.860
EAS	815.820	6.630	38.240	5.280	86.330	-	250.710	428.640
SOA	989.560	-	118.790	17.960	23.740	-	488.840	340.240
MEA	722.010	-	-	196.030	8.120	-	457.260	60.600
LAT	888.580	9.980	10.720	17.380	66.570	-	347.800	436.140
ARW	363.360	-	0.710	-	22.020	1.670	267.290	71.670
TOTAL	25,649.340	99.610	2,811.240	383.940	2,948.080	1,302.670	7,646.260	10,457.560

24. NFT-NAFTA (US, Canada, Mexico); WEU-Western Europe; CEU-Central and Eastern Europe; JPK-Japan and Korea; ANZ-Australia and New Zealand; FSU-Former Soviet Union; CHN-China; EAS-East Asia; SOA-South Asia; MEA-Middle East; LAT-Latin America; ARW- Africa and Rest of World.

ANNEX 13:
Energy efficiency initiatives

The European chemicals industry has been implementing a Voluntary Energy Efficiency Programme (VEEP) since 1992. VEEP2005 is a unilateral commitment by the industry to reduce its specific energy consumption by a further 20% between 1990 and 2005, and it is on course to meet that target. CEFIC believe that the increasingly efficient use of energy is the most promising route to sustainable development, particularly since it contributes simultaneously to reductions in greenhouse gas emissions and to improved international competitiveness. At national level, various chemical sectors have entered into long-term agreements for energy improvements with their respective governments. At company level, major contributions to improved efficiency have come about from the construction of new process plants and the application of new technologies, and through co-generation whereby electricity and steam are produced simultaneously with surplus electricity usually being delivered to the grid. However, there is a caveat to VEEP2005 – the industry is committed to the energy efficiency targets provided that no additional energy taxes are introduced. CEFIC consider that the taxation of energy is a threat to their competitiveness in world markets. They believe it is an inappropriate instrument for achieving energy conservation and for stabilising greenhouse gas emissions since it deprives the industry of the funds it needs to invest in further energy efficiency improvements and new technologies.

Improvements in unit energy consumption by the chemicals industry in Japan have come about through developments of energy saving technologies, modernisation of production facilities and switching products. Under the Japan Chemical Industries Association (JCIA) Voluntary Environmental Action Plan, the chemicals industry is making efforts to reduce unit energy consumption to 90% of 1990 levels by 2010, although it appears that this would only keep CO_2 emissions relatively constant, presumably due to anticipated production increases. This action plan was developed by the JCIA against the background of discussions on climate change and in response to a request by the Federation of Economic Organisations of Japan at the end of 1996 that each industrial sector submit its own Environmental Preservation Initiative Action Plan. In addition to improvements in unit energy consumption, the JCIA has also committed to:

- Endeavour to develop energy-saving and environmentally-harmonized process technologies by effectively utilising catalyst, biological, oil processing, gas processing and other technologies owned by the industry.

- In promoting overseas projects, transfer energy-saving and environmental preservation technologies to developing countries and contribute to reducing CO_2 emissions in these countries.

In Canada, two public voluntary programmes (the Canadian Industry Programme for Energy Conservation and the Voluntary Challenge and Registration Programme) play an important role in fulfilling commitments under the Kyoto climate change protocol regarding reductions in industrial greenhouse gas emissions. Both programmes are primarily performance reporting systems, rather than

target focused. In the US, the Chemical Manufacturers Association promotes a similar voluntary Energy Efficiency Programme.

For the petrochemicals industry, a recent study (Gielen and Groenendaal 1999) reported that GHG emission reduction will have a significant impact on the selection of feedstocks by industry, on the selection of process technologies, and on the waste management strategies for the industry's products. From model calculations, the study suggested that the main greenhouse gas emission strategy should be feedstock substitution (65% of emission reduction), followed by N_2O emission mitigation (15%), recycling/energy recovery (10%) and increased materials efficiency (10%).

Possibilities for feedstock substitution include the use of ethane instead of naphtha in steam cracking and the use of methanol and/or ethanol from biomass to produce ethylene and propylene. Reduction of industrial N_2O emissions from the production of adipic acid (an intermediate in nylon production) can best be removed in exhaust gases. Many new plastic waste recycling technologies have been developed during the last decade, and greenhouse gas emission permit pricing could increase the cost-effectiveness of these recycling strategies significantly. Changing materials use can involve using materials more efficiently so that less are used, using other materials (*e.g.* renewables), and recycling petrochemical products and plastics in particular. Energy-related strategies include increasing energy efficiency, fuel substitution and end of the pipe CO_2 removal, and underground storage. Possibilities for improving energy efficiency are thought to be limited (the industry is already quite efficient) as are CO_2 reductions from end of pipe approaches. Fuel substitution could be achieved through a switch to renewable energy carriers or electricity based on CO_2-free energy sources.

The development of such strategies will require significant R&D efforts, but could simultaneously enhance the sustainability of the petrochemicals industry.

ANNEX 14: CO_2 emissions from the chemicals industry, all industries and all sectors (1995 - 2020)

*(*Source: *OECD Reference Scenario)*

	REGION	by YEAR (totals in Gt)			Average Annual Change	Total Change
		1995	2010	2020	1995-2020	1995-2020
Chemicals Industry	**Aust+NZ**	6,168,427	8,742,814	10,188,188	2.0%	65%
	Cent+E. Europe	36,981,656	67,333,502	97,425,375	4.0%	163%
	Japan+Korea	56,148,931	67,821,242	78,266,338	1.3%	39%
	Mexico	23,735,132	33,654,310	40,827,292	2.2%	72%
	N. Amer	231,134,688	324,868,787	390,752,585	2.1%	69%
	W. Europe	132,659,076	171,294,269	192,954,837	1.5%	45%
	Africa	9,135,402	13,454,674	18,113,799	2.8%	98%
	Cent+S. Amer	35,966,079	49,309,790	65,826,607	2.4%	83%
	China	248,128,520	522,661,229	715,362,771	4.3%	188%
	E. Asia	29,850,264	56,087,021	90,357,320	4.5%	203%
	FSU	44,788,889	60,308,679	94,850,448	3.0%	112%
	Mid East	26,183,039	38,277,837	49,759,284	2.6%	90%
	ROE	2,209,009	3,261,505	4,390,577	2.8%	99%
	ARW	2,845,610	4,186,944	5,634,509	2.8%	98%
	S. Asia	53,222,573	101,290,569	153,997,951	4.3%	189%
	OECD	486,827,910	673,714,924	810,414,615	2.1%	66%
	non-OECD	452,329,385	848,838,248	1,198,293,266	4.0%	165%
	World	939,157,295	1,522,553,172	2,008,707,881	3.1%	114%
All Industries	**OECD Industry**	2,189,116,814	2,868,612,231	3,373,992,310	1.8%	54%
	non-OECD Industry	2,553,827,939	4,701,035,848	6,685,619,100	4.2%	162%
	World Industry	4,742,944,753	7,569,648,079	10,059,611,410	3.2%	112%
All Sectors	**OECD All Sectors**	12,667,492,425	15,122,760,697	16,801,623,530	1.2%	33%
	non-OECD All Sectors	9,862,094,413	14,760,470,927	19,566,857,629	2.7%	98%
	World All Sectors	22,529,586,838	29,883,231,624	36,368,481,159	1.9%	61%

FSU – Former Soviet Union/**ROE** – Rest of Europe/**ARW** –Africa and Rest of World

ANNEX 15: Production of CFCs for selected countries and regions[25]

*(*Source: *UNEP, 1999)*

In ODP tons (i.e. metric tons times ozone depletion potential)

	1986	1989	1990	1991	1992	1993	1994	1995	1996	1997
OECD total	920,946	889,224	627,728	542,707	479,131	398,273	208,603	124,737	51,673	52,084
NFT	338,734	347,677	222,232	190,278	176,388	141,372	93,625	50,465	9,635	9,170
WEU	443,446	366,819	277,378	234,865	219,431	189,639	79,865	30,599	32,705	33,498
CEU	1,978	2,122	1,816	1,510	1,203	897	231	320	7	12
JPK	121,403	154,993	118,039	108,569	75,356	59,721	30,429	39,503	9,326	9,404
ANZ	15,385	17,613	8,263	7,485	6,753	6,644	4,452	3,850	0	0
CHN	11,540	20,700	20,688	26,018	24,941	31,658	50,809	46,672	44,016	50,324

25. NFT-NAFTA (US, Canada, Mexico); WEU-Western Europe; CEU-Central and Eastern Europe; JPK-Japan and Korea; ANZ-Australia and New Zealand; CHN-China.

ANNEX 16: Summary of OECD Member Country PRTR Activities

	First year of data collection	Environmental media covered	Mandatory or voluntary system	Number of listed chemicals	Transfers offsite included	Reporting of public facilities	Diffuse sources included	Report cycle	Public Dissemination of full (raw) data	Public Dissemination of aggregated data sets	Pilot Study	Consultation with affected and interested parties on design	Site specific reporting
Australia	1998	A,W,L	Mandatory	90	No	Yes	Yes	Annual	Yes	Yes	Yes	Yes	Yes
Austria[1]	N/A												
Belgium Fl. (Air)	1993	Air	Mandatory [2]	63		No	Yes	Annual	No	Yes	Yes	Yes	Yes
Belgium Fl. (Water)	1993	Water	Mandatory	162	Yes	No	No [3]	Annual	No	Yes	No	No	Yes
Canada	1993	A,W,L	Mandatory	245	Yes	Yes	Yes	Annual	Yes	Yes	Yes	Yes	Yes
Czech Republic	N/A	A,W,L	Mandatory	N/A	Yes	Yes	No	N/A	No	Yes	Yes	Yes	Yes
Denmark	1989	Water	Mandatory	300	Yes	Yes	No	Annual	Yes	Yes	Yes	Yes	Yes
Finland	1988	A,W,L	Mandatory	50	No	Yes	No	Annual	No	Yes	Yes	No	Yes
Hungary	N/A	A,W,L	Mandatory	200-250	Yes	N/A	No	N/A	N/A	N/A	Planned	Yes	Yes
Ireland	1995	A,W,L	Mandatory	PER list [4]	Yes	Yes	No	Annual	Yes	Yes	No	Yes	Yes
Italy	1995	Land	Mandatory		Yes	Yes	No	Annual	Yes	Yes	Yes	Yes	Yes
Japan	2001	A,W,L	Mandatory	354	Yes	Yes [5]	Yes	Annual	No [6]	Yes	Yes	Yes	Yes
Korea	1999	A,W,L	Mandatory	80	Yes	Yes	Yes	Annual	Yes	Yes	Yes	Yes	Yes
Mexico	1997	A,W,L	Both	191	Yes	Yes	No	Annual	No	Yes	Yes	Yes	Yes
Netherlands	1976 [7]	A,W,L	Mandatory	180	Yes	Yes	Yes	Annual	Yes	Yes	Yes	Yes	Yes
Norway	1992	A,W,L	Mandatory	250	Yes	Yes	Yes	Annual	No [8]	Yes	No	No	Yes
Slovak Republic	1998	A,W	Both	200	Yes	Yes	No	Annual	Yes	Yes	Yes	Yes	Yes
Sweden	N/A	A,W,L	Mandatory	N/A	N/A	N/A	Yes	N/A	N/A	N/A	Yes	Yes	Yes
Switzerland	2001	A,W	Voluntary	50	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	N/A
United Kingdom	1991 [9]	A,W,L	Mandatory	183	No	Yes	Yes	Annual	Yes	Yes	No	Yes	Yes
United States	1987	A,W,L	Mandatory	643	Yes	Yes	No	Annual	Yes	Yes	No	Yes	Yes

A,W,L = Air, Water, Land

N/A = Not available or not answered

1. No PRTR or plans to develop a PRTR at this time

2. Started in 1980 as voluntary; since 1993, it is mandatory

3. Waste Register

4. Available through Republic of Ireland EPA, P.O. Box 300, Johnstown Castle Estate, Co. Wexford, Ireland

5. Planned

6. To be provided when requested

7. 1999 for new system

8. In 2000, data will be available on Internet

9. 1998 for new system

This table is primarily based on responses made by governments to a 1999 OECD PRTR questionnaire and has been updated for this report. Operating systems as of June 1999 are highlighted in gray.

ANNEX 17:
Releases of 1988 "Core"[26] chemicals by the US chemicals industry

(*Source:* US EPA, 2000a)

In millions of pounds

	Total air emissions	Underground injection	Releases to land	Surface water discharges	Total off-site releases	Chemicals industry total	Industry total
1988	583	159	97	140	74	1,053	3,396
1990	448	156	83	85	64	836	2,918
1992	392	117	72	165	38	783	2,405
1994	303	112	72	27	32	547	2,061
1996	269	121	70	32	30	523	1,919
1998	200	113	72	31	38	454	1,856

Note: *The 1998 Industry total does not include the seven industries added to the TRI Program in 1998 (*i.e.*, metal mining, coal mining, electric utilities, chemical distributors, petroleum bulk terminals, hazardous waste treatment and disposal facilities and solvent recovery services).*

26. "Core chemicals" are those chemicals that were on the TRI list in both 1988 and 1998 and does not include substances added or deleted in the interim.

ANNEX 18A:

(*Source*: OECD, 1999d)

Consumption of pesticides (a), latest year available
Consommation de pesticides (a), dernière année disponible

tonnes (active ingredients/éléments actifs)

		Year/ Année	Total pesticides	Insecticides	Fungicides/ Fongicides	Herbicides	Other pesticides/ Autres pesticides
Canada	*	1994	29206	3426	3780	21910	90
Mexico/ Mexique		1993	36000	..	..	..	..
USA/ Etats-Unis	*	1993	367863	77564	72121	218178	..
Japan/ Japon	*	1993	64500	..	..	..	..
Korea/ Corée		1997	24814	9161	7332	6043	2278
Australia/ie		1992	119654	7430	94193	18031	..
N.Zealand/ N.Zélande		1996	3499	485	1002	1886	126
Austria/ Autriche		1997	3690	389	1688	1601	12
Belgium/ Belgique	*	1993	9885	1118	2781	5587	383
Czech Rep./ Rép.tchèque	*	1997	3889	103	907	2547	332
Denmark/ Danemark	*	1997	3675	51	794	2726	104
Finland/ Finlande	*	1997	1016	47	154	734	81
France	*	1997	109792	6074	64050	33576	6092
Germany/ Allemagne	*	1997	34648	4697	9397	16485	4069
Greece/ Grèce	*	1997	9034	2436	3104	2116	1378
Hungary/ Hongrie		1995	7696	1077	2063	3724	832
Iceland/ Islande		..	..	..	..	..	..
Ireland/ Irlande	*	1997	2325	73	679	1261	312
Italy/ Italie	*	1997	167089	39161	84450	28889	14589
Luxembourg		1991	253	10	113	121	9
Netherlands/ Pays-Bas	*	1997	10397	1296	4356	2984	1761
Norway/ Norvège	*	1997	754	18	175	504	57
Poland/ Pologne	*	1997	9501	581	3058	5167	695
Portugal	*	1996	12457	727	9746	1584	400
Spain/ Espagne	*	1997	34023	9944	11299	9153	3627
Sweden/ Suède	*	1997	1527	19	246	1236	26
Switzerland/ Suisse	*	1996	1747	209	890	625	23
Turkey/ Turquie	*	1995	33243	14850	4937	7583	5873
UK/ Royaume-Uni	*	1997	35432	921	6615	24095	3801
Slovak Rep./ Rép.slovaque		1997	3512	159	506	2523	324
Russian Fed./ Féd. Russie		1996	17200	800	800	14800	800

Notes (23a):

a) Unless otherwise specified, data refer to active ingredients. Insecticides: acaricides, molluscicides, nematocides and mineral oils. Fungicides bactericides and seed treatments. Herbicides: defoliants and dessicants. Other pesticides: plant growth regulators and rodenticides.

CAN) 1994 data refer to agriculture uses only (non-agricultural uses excluded). Insecticides: data exclude Bacillus thuringiensis. Other pesticides: include growth regulators, animal repellents, rodenticides, and fumigants

USA) Agricultural pesticides only. Fungicides: include other pesticides.

JPN) Data refer to national production of pesticides.

BEL) Data include Luxembourg.

CZE) Data refer to agricultural pesticides and sales of chemical p esticides. Other pesticides: include growth regulators, rodenticides, animal repellents, additives, adhesives and other pesticides.

DNK) Data refer to sales for use in plant production in open agriculture.

FIN) Data include forest pesticides and refer tosales.

FRA) Data refer to quantities sold to agriculture. Fungicides: include copper and sulphur compounds but not elemental sulphur.

DEU) Data refer to sales.

GRC) Data refer to sales.

IRL) 1994-97: data based on pesticide imports, which gives a reasona ble estimation of the quantities used as the country imports most of its pesticides.

ITA) Data refer to formulation weight.

NLD) Data refer to sales of chemical pesticides. Other: include soil disinfectants which for the years presented correspond to about half of total consumption.

NOR) Data refer to sales.

POL) Other: incl. growth regulators, rodenticides, animal repellents and others.

PRT) Data refer to sales.

ESP) Data refer to sales.

SWE) Data refer to sales.

CHE) Data refer to sales and have been estimated to represent 95 per cent of the total market volume; Liechtenstein included.

TUR) Formulation weight. Powdered sulphur and copper sulphate excluded.

UKD) Great Britain only. Data for herbicides include the desiccant sulphuric acid, which represents from 17% (1988) to 38% (1994) of the total of all pesticides. Data are for all areas of agriculture and horticulture. Pesticides used as veterinary medicines (e.g. sheep dips) have been excluded.

Notes (23a) :

a) Les données se rapportent aux éléments actifs. Insecticides: acaricides, mollusquicides, nématocides et huiles minérales. Fongicides: bactericides et traitements de semences. Herbicides: défoliants et déssicants. Autres pesticides: régulateurs de croissance et les rodenticides.

CAN) 1994: Inclut des usages agricoles uniquement (usages non agricoles exclus). Insecticides: exclut le Bacillus thuringiensis. Autres pesticides: incluent les régulateurs de croissance, les répulseurs d'animaux, les rodenticides et les fumigants.

USA) Uniquement les pesticides agricoles. Fongicides: incluent autres pesticides.

JPN) Les données se réfèrent à la production nationale de pesticides.

BEL) Les données incluent le Luxembourg.

CZE) Les données se réfèrent aux pesticides agricoles et aux ventes de pesticides chimiques. Autres pesticides: incluent les régulateurs de croissance, les rodenticides, les répulseurs d'animaux, les additifs, les adhésifs et autres pesticides.

DNK) Les données se réfèrent aux ventes pour la production agricole en plein air.

FIN) Les données incluent les pesticides forestiers et se réfèrent aux ventes.

FRA) Quantités vendues pour l'usage agricole. Fongicides: comprennent les composés à base de cuivre et de soufre mais non le soufre en l'état.

DEU) Les données se réfèrent aux ventes.

GRC) Les données se réfèrent aux ventes.

IRL) 1994-97: données basées sur les importations de pesticides, ce qui donne une estimation raisonnable des quantités utilisées, puisque le pays importe la plupart de ses pesticides.

ITA) Les données se rapportent au poids total de produit préparé.

NLD) Données concernant les ventes des pesticides chimiques. Autres: incl. les désinfectant qui correspondent env., pour les années considérées, à la moitié de la consommation totale.

NOR) Les données se réfèrent aux ventes.

POL) Autres: incl. régulateurs de croissance, rodenticides, répulseurs d'animaux, et autres.

PRT) Les données se réfèrent aux ventes.

ESP) Les données se réfèrent aux ventes.

SWE) Les données se réfèrent aux ventes.

CHE) Les données se réfèrent aux ventes et elles étaient estimées pour représenter 95 pour cent du volume totale du marché; Liechtenstein inclut.

TUR) Les données se rapportent au poids total de produit préparé. Le soufre en poudre et le sulphate de cuivre sont exclus.

UKD) Grande Bretagne uniquement. Herbicides: incluent l'acide sulphurique déssicant, qui représente de 17% (1988) à 38% (1994) du total de tous les pesticides. Les données se rapportent à tous les secteurs de l'agriculture et de l'horticulture. Les pesticides utilisés en médecine vétérinaire (ex. bains parasiticides pour moutons) sont exclus.

Source: FAO, national statistical yearbooks, UNECE, UNEP, ECPA/ FAO, annuaires statistiques nationaux, CEENU, PNUE,

ANNEX 18B

(Source: *OECD, 1999d*)

Trends in the consumption of pesticides (a), 1980-1997
Evolution de la consommation de pesticides (a), 1980-1997

		Tonnes		Index 1985 = 100[a]													
		Base year/année de réf.		1980	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Canada	* Insecticides	3172		..	100	90	94	86	..	57	..	..	..	108	..	..	..
	Fungicides/Fong.	2823		..	100	120	97	92	..	90	..	..	..	134	..	..	..
	Herbicides	30181		..	100	82	83	92	..	90	..	..	..	73	..	..	..
	Total pesticides	39259		..	100	84	86	90	..	87	..	..	..	74	..	..	..
USA/	* Insecticides	102150		136	100	93	80	82	67	77	78	80	76	..	..	..	..
Etats-Unis	Fungicides/Fong.	50394		86	100	117	135	135	122	131	132	132	143	..	..	..	..
	Herbicides	238350		87	100	95	96	97	99	98	94	97	92	..	..	..	..
	Total pesticides	390894		99	100	95	95	98	94	97	95	97	94	..	..	..	..
Japan/	* Insecticides	45018		100	100	..	..	..	..	..	..	..	..	..	..	..	..
Japon	Fungicides/Fong.	18622		103	100	..	..	..	..	..	..	..	..	..	..	..	..
	Herbicides	19416		133	100	..	..	..	..	..	..	..	..	..	..	..	..
	Total pesticides	83056		108	100	95	92	84	83	82	79	78	78	..	..	..	..
Korea/	Insecticides	7834	(1986)	..	..	100	103	93	101	119	134	126	98	102	114	107	117
Corée	Fungicides/Fong.	7054	(1986)	..	..	100	119	115	114	110	120	120	144	143	112	100	104
	Herbicides	4454	(1986)	..	..	100	105	103	110	124	126	121	118	124	131	134	136
	Total pesticides	21322	(1986)	..	..	100	109	103	109	118	129	125	122	123	121	115	116
N.Zealand/	Insecticides	473	(1994)	..	..	..	..	..	..	..	..	..	..	100	109	103	..
N.Zélande	Fungicides/Fong.	910	(1994)	..	..	..	..	..	..	..	..	..	..	100	102	110	..
	Herbicides	2039	(1994)	..	..	..	..	..	..	..	..	..	..	100	115	92	..
	Total pesticides	3515	(1994)	..	91	..	91	..	..	..	..	..	99	100	111	100	..
Austria/	Insecticides	428		80	100	117	..	..	..	..	101	111	109	109	86	74	91
Autriche	Fungicides/Fong.	2072		81	100	117	..	..	72	81	89	72	76	75	68	82	81
	Herbicides	2648		83	100	115	..	..	97	73	82	70	71	58	61	58	60
	Total pesticides	5270		82	100	115	..	..	88	81	85	74	76	69	65	68	70
Belgium/	* Insecticides	1669		94	100	91	82	83	82	77	70	76	67	..	..	..	..
Belgique	Fungicides/Fong.	2123		51	100	103	105	122	124	129	134	155	131	..	..	..	..
	Herbicides	4617		99	100	100	105	112	114	113	110	111	121	..	..	..	..
	Total pesticides	8748		85	100	100	102	109	113	114	110	115	113	109	120	114	99
Czech Rep./	* Insecticides	665	(1989)	..	..	..	..	..	100	78	54	49	28	21	17	16	15
Rép. tchèque	Fungicides/Fong.	1809	(1989)	..	..	..	..	..	100	98	84	58	52	44	54	62	50
	Herbicides	7816	(1989)	..	..	..	..	..	100	80	52	40	29	32	32	31	33
	Total pesticides	11217	(1989)	..	..	..	..	..	100	80	57	43	32	33	34	35	35
Denmark/	* Insecticides	262		..	100	89	60	57	86	99	56	49	41	36	62	14	19
Danemark	Fungicides/Fong.	2199		..	100	76	51	49	58	63	65	61	47	41	48	29	36
	Herbicides	4079		..	100	93	96	92	97	77	70	69	65	66	80	71	67
	Total pesticides	6863		..	100	89	80	77	84	82	67	67	60	57	70	53	54
Finland/	* Insecticides	144		130	100	97	89	148	136	67	44	64	86	51	40	38	33
Finlande	Fungicides/Fong.	110		90	100	101	92	131	162	148	133	176	191	190	104	105	140
	Herbicides	1566		134	100	98	102	91	109	101	88	64	54	59	51	43	47
	Total pesticides	1964		130	100	98	101	98	115	104	88	72	64	66	54	48	52
France	* Insecticides	6258		75	100	114	104	106	114	123	113	98	86	73	113	86	97
	Fungicides/Fong.	48569		82	100	101	93	102	95	85	114	92	112	102	88	100	132
	Herbicides	36320		89	100	99	94	99	100	103	93	75	72	82	75	99	92
	Total pesticides	98027		84	100	102	95	101	102	100	106	86	94	91	86	100	112
Germany/	* Insecticides	3901	(1991)	..	..	..	..	..	..	..	100	105	111	103	126	97	120
Allemagne	Fungicides/Fong.	9760	(1991)	..	..	..	..	..	..	..	100	96	78	79	99	107	96
	Herbicides	18992	(1991)	..	..	..	..	..	..	..	100	82	67	78	85	87	87
	Total pesticides	36937	(1991)	..	..	..	..	..	..	..	100	91	78	81	93	95	94
Greece/	* Insecticides	3119	(1986)	..	..	100	88	93	102	..	69	73	76	99	81	78	78
Grèce	Fungicides/Fong.	2056	(1986)	..	..	100	94	80	94	..	123	133	120	152	149	158	151
	Herbicides	2158	(1986)	..	..	100	85	103	140	..	96	99	107	110	99	126	98
	Total pesticides	7346	(1986)	..	..	100	89	92	111	..	107	117	117	136	116	134	123
Hungary/	Insecticides	5577		57	100	89	66	59	75	47	32	22	27	24	19	..	..
Hongrie	Fungicides/Fong.	9157		164	100	149	120	124	180	128	57	46	28	31	23	..	..
	Herbicides	10763		127	100	120	110	97	136	102	84	57	52	43	35	..	..
	Total pesticides	26342		128	100	121	102	96	135	97	61	44	39	36	29	..	..
Ireland/	Insecticides	40	(1988)	461	..	..	..	100	..	373	405	360	..	275	265	163	183
Irlande	Fungicides/Fong.	544	(1988)	39	..	..	..	100	99	85	98	122	119	121	99	97	125
	Herbicides	1089	(1988)	96	..	..	..	100	103	90	101	92	110	99	125	81	116
	Total pesticides	1812	(1988)	81	..	..	..	100	105	96	106	107	120	119	124	96	128
Italy/	* Insecticides	34401		95	100	97	96	107	104	101	96	95	98	92	102	98	114
Italie	Fungicides/Fong.	85126		187	100	110	135	136	124	125	105	111	111	98	99	97	99
	Herbicides	28525		78	100	104	110	109	101	94	91	79	86	87	95	101	101
	Total pesticides	166839		139	100	108	120	125	117	115	103	102	103	95	99	99	100
Netherlands/	* Insecticides	634		..	100	88	79	236	255	310	280	278	335	288	235	279	204
Pays-Bas	Fungicides/Fong.	4363		..	100	82	93	95	93	95	98	96	92	89	91	83	100
	Herbicides	3977		..	100	95	98	92	84	87	81	75	70	67	77	76	75
	Total pesticides	21002		..	100	103	86	87	91	90	82	76	56	53	52	49	50

ANNEX 18B (continued)

Trends in the consumption of pesticides (a), 1980-1997
Evolution de la consommation de pesticides (a), 1980-1997

		Tonnes		Index 1985 = 100[a]													
		Base year/année de réf.		1980	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Norway/	* Insecticides	39		93	100	122	83	98	70	49	47	69	43	54	49	37	46
Norvège	Fungicides/Fong.	138		70	100	104	80	78	87	111	104	108	130	114	121	101	127
	Herbicides	1236		97	100	96	86	74	69	78	46	45	41	51	56	41	41
	Total pesticides	1529		90	100	99	87	78	68	77	50	51	50	56	61	46	49
Poland/	* Insecticides	1305	(1986)	..	..	100	97	97	82	..	26	28	31	23	34	33	45
Pologne	Fungicides/Fong.	3622	(1986)	..	..	100	147	190	199	..	38	54	51	64	63	82	84
	Herbicides	9035	(1986)	..	..	100	126	154	131	..	33	46	48	47	44	61	57
	Total pesticides	14479	(1986)	64	86	100	127	161	142	52	36	47	47	51	48	65	66
Portugal	* Insecticides	763	(1984)	90	..	..	..	..	..	..	109	99	102	95	87	95	..
	Fungicides/Fong.	14021	(1984)	148	..	..	..	..	..	..	46	28	48	51	65	70	..
	Herbicides	1074	(1984)	104	..	..	..	..	..	..	168	111	122	146	155	147	..
	Total pesticides	15966	(1984)	142	..	..	..	..	..	..	59	38	56	60	74	78	..
Spain/	* Insecticides	13148	(1986)	..	..	100	121	112	102	70	70	51	45	81	73	74	76
Espagne	Fungicides/Fong.	8464	(1986)	..	..	100	130	152	153	145	137	121	110	122	107	120	133
	Herbicides	10822	(1986)	..	..	100	93	107	106	124	127	111	98	67	58	80	85
	Total pesticides	39134	(1986)	..	..	100	113	122	119	101	100	81	75	80	71	85	87
Sweden/	* Insecticides	140		122	100	108	37	74	28	19	14	21	11	29	12	9	14
Suède	Fungicides/Fong.	639		78	100	156	80	106	78	101	113	81	50	58	31	40	38
	Herbicides	2752		136	100	152	64	73	67	59	38	34	40	55	35	45	45
	Total pesticides	3660		121	100	153	66	78	66	64	50	41	40	54	33	42	42
Switzerland/	* Insecticides	385	(1988)	31	..	..	..	100	93	101	75	70	62	64	48	54	..
Suisse	Fungicides/Fong.	1120	(1988)	100	..	..	..	100	99	88	81	85	88	87	85	79	..
	Herbicides	885	(1988)	93	..	..	..	100	105	93	88	85	76	75	74	71	..
	Total pesticides	2456	(1988)	84	..	..	..	100	100	93	84	82	79	78	74	71	..
Turkey/	* Insecticides	20336		67	100	113	73	74	92	87	51	65	60	55	73	..	..
Turquie	Fungicides/Fong.	5804		76	100	102	105	110	101	95	96	102	101	84	85	..	..
	Herbicides	6839		62	100	87	109	115	90	93	105	86	134	124	111	..	..
	Total pesticides	36662		73	100	107	90	93	96	93	77	81	88	79	91	99	92
UK/	* Insecticides	1358		127	100	93	103	110	110	99	99	82	84	103	98	66	68
Royaume-	Fungicides/Fong.	5116		101	100	101	98	146	146	143	143	134	137	126	125	131	129
Uni	Herbicides	30730		82	100	99	99	68	67	76	76	66	68	74	74	78	78
	Total pesticides	40826		82	100	100	100	81	80	88	87	78	79	83	83	87	87
Slovak Rep./	Insecticides	495	(1991)	..	..	..	..	..	..	..	100	25	57	54	67	43	32
République	Fungicides/Fong.	1102	(1991)	..	..	..	..	..	..	..	100	51	58	51	112	61	46
slovaque	Herbicides	3116	(1991)	..	..	..	..	..	..	..	100	57	95	106	90	80	81
	Total pesticides	4713	(1991)	404	282	272	249	..	..	..	100	52	86	97	101	83	75
Russian	Insecticides	45900	(1989)	..	..	..	..	..	100	52	51	23	..	2	2	2	..
Federation/	Fungicides/Fong.	33700	(1989)	..	..	..	..	..	100	77	67	29	..	1	3	2	..
Féd. Russie	Herbicides	69300	(1989)	..	..	..	..	..	100	51	65	48	..	30	31	21	..
	Total pesticides	150400	(1989)	..	..	..	..	..	100	57	61	36	29	15	17	11	..

Notes: See next page/voir page suivante

Notes (23b):

a) Unless otherwise specified, data refer to active ingredients and the reference year is 1985. Insecticides: acaricides, molluscicides, nematocides and mineral oils. Fungicides: bactericides and seed treatments. Herbicides: defoliants and dessicants. Total pesticides may include other pesticides such as plant growth regulators and rodenticides.

CAN) Survey coverage has varied greatly (different active ingredients, registrants and products); survey trends therefore may not reflect actual trends but simply changes in the survey coverage. Data include non-agricultural uses, such as home and garden plants, golf course, etc; they represent, however, a small part of the total use (between 1 and 6% of the total depending on category). 1994: data refer to agriculture uses only (non-agricultural uses excluded). Insecticides: data exclude Bacillus thuringiensis. Total: includes animal repellents and fumigants.

USA) Agricultural pesticides only. Fungicides: incl ude other pesticides.

JPN) Data refer to national production of pesticides.

BEL) Data include Luxembourg.

CZE) Data refer to agricultural pesticides and sales of chemical pesticides. Total: animal repellents, additives, adhesives and other pesticides.

DNK) Data refer to sales for use in plant production in open agriculture.

FIN) Data refer to sales. Total: includes forest pesticides.

FRA) Data refer to quantities sold to agriculture. Fungicides: include copper and sulphur compounds but not elemental sulphur.

DEU) Data refer to sales.

GRC) Data refer to sales.

ITA) From 1981, data include only agricultural pesticides. Data refer to formulation weight. Active ingredients (in tonnes) represent on 1990 insecticides: 10 943; fungicides: 58 473; herbicides: 10 267; and total (including others): 91 671.

NLD) Sales of chemical pesticides. Total: includes soil disinfectants which correspond, for the years presented, to about the half of the total consumption.

NOR) Data refer to sales.

POL) Total: includes animalrepellents and other pesticides.

PRT) Data refer to sales. 1991-94 data do not include all sales (some entreprises trading in these substances are excluded); since 1995 data refer to all sales (all entreprises included). The increase in sales for 1995 corresponding to the increase in the number of entreprises covered was about 12%. Fungicides: the decrease from 1984 to 1991 results, mainly from the replacement of powdered sulphur with other active substances, which are used in much smaller quantities. The decrease of sales in 1992 results from the 1991-92 years drought, which led to a decrease in the agricultural activity.

ESP) Data refer to sales.

SWE) A special sales tax has been applied to pesticides since 1987. Another tax was applied in 1995. Data refer to sales.

CHE) Data refer to sales and have been estimated to represent 95% of the total market volume; Liechtenstein included.

TUR) Formulation weight. Powdered sulphur and copper sulphate excluded.

UKD) Great Britain only. Data for herbicides includ e the desiccant sulphuric acid, which represents from 17% (1988) to 38% (1994) of the total of all pesticides. Data are for all areas of agriculture and horticulture. Pesticides used as veterinary medicines (e.g. sheep dips) have been excluded.

Notes (23b):

a) Les données se rapportent aux éléments actifs et l'année de référence est 1985 sauf en cas d'indication contraire. Insecticides: acaricides, mollusquicides, nématocides et huiles minérales. Fongicides: bactericides et traitements de semences. Herbicides: défoliants et déssicants. Le total des pesticides peut inclure d'autres pesticides tels que les régulateurs de croissance des plantes et les rodenticides.

CAN) La couverture de l'enquête varie dans le temps (différentes substances actives, marques et produits); l'évolution observée peut ne pas traduire une tendance réelle mais simplement des changements dus à la couverture de l'enquête. Incluent des usages non agricoles comme les plantations de jardin et d'intérieur, terrains de golf, etc; ceci représente, cependant, une petite partie de l'utilisation totale (entre 1 et 6% du total selon les différentes catégories). 1994: inclut des usages agricoles uniquement (usages non agricoles exclus). Insecticides: exclut le Bacillus thuringiensis. Total: inclut les répulseurs d'animaux et les fumigants.

USA) Uniquement les pesticides agricoles. Fongicides: incluent autres pesticides.

JPN) Données fondées sur la production nationale de pesticides.

BEL) Les données incluent le Luxembourg.

CZE) Les données se rapportent aux pesticides agricoles et aux ventes de pesticides chimiques. Total: répulseurs d'animaux, additifs, adhésifs et autres pesticides.

DNK) Les données se réfèrent aux ventes pour la production agricole en plein air.

FIN) Les données se réfèrent aux ventes. Total: inclut les pesticides forestiers.

FRA) Les données concernent les quantités vendues pour l'usage agricole. Fongicides: comprennent les composés à base de cuivre et de soufre mais non le soufre en l'état.

DEU) Les données se réfèrent aux ventes.

GRC) Les données se réfèrent aux ventes.

ITA) Depuis 1981, les données ne comprennent que les pesticides agricoles. Les données se rapportent au poids total de produit préparé. Les données en substance actives (en tonnes) pour l'année 1990 représentent: insecticides: 10 943; fongicides: 58 473; herbicides: 10 267; et total (incluant autres): 91 671.

NLD) Ventes des pesticides chimiques. Total: inclut les désinfectants qui correspondent environ, pour les années considérées, à la moitié de la consommation totale.

NOR) Les données se réfèrent aux ventes.

POL) Total: inclut les répulseurs d'animaux et les autres pesticides.

PRT) Les données se réfèrent aux ventes. Les données 1991-94 n'incluent pas la totalité des ventes (quelques sociétés vendant ces produits sont exclues); depuis 1995 les données concernent la totalité des ventes (toutes sociétés comprises). L'augmentation des ventes en 1995 est due au plus grand nombre d'entreprises (environ 12%). Fongicides: la diminution observée de 1984 à 1991 résulte, principalement, de la substitution du soufre par d'autres substances actives, qui sont utilisées en plus petites quantités. La baisse des ventes en 1992 est due à la sécheresse de 1991-92 qui mena à une baisse de l'activité agricole.

ESP) Les données seréfèrent aux ventes.

SWE) Depuis 1987, une taxe spéciale est appliquée aux ventes de pesticides. Une autre taxe était appliquée en 1995. Les données se réfèrent aux ventes.

CHE) Les données se réfèrent aux ventes et étaient estimées pour représenter 95% du volume totale du marché; Liechtenstein inclut.

TUR) Les données se rapportent au poids total de produit préparé. Le soufre en poudre et le sulphate de cuivre sont exclus.

UKD) Grande Bretagne uniquement. Les données pour les herbicides incluent l'acide sulphurique déssicant, qui représente de 17% (1988) à 38% (1994) du total de tous les pesticides. Les données se rapportent à tous les secteurs de l'agriculture et de l'horticulture. Les pesticides utilisés comme médecine vétérinaire (ex. bains parasiticides pour moutons) sont exclus.

Source: FAO, national statistical yearbooks, UNECE, UNEP, ECPA/ FAO, annuaires statistiques nationaux, CEENU, PNUE, ECPA

ANNEX 19:
Examples of successful voluntary chemical management programmes

Examples of *public voluntary programmes* being used by the chemicals industry include environmental management certification programmes such as the EU system EMAS (Eco-management and Auditing Scheme) and ISO 14000. Public voluntary programmes are the most common types of voluntary agreements used in the US. They are set unilaterally by the Environmental Protection Agency and take the form of take-it-or-leave-it options offered to companies. There are no provisions for enforcement, and companies' incentives to join the programmes are partly driven by public image considerations. The focus of the US voluntary programmes is primarily on meeting goals of the 1993 Climate Change Action Plan or to adopt voluntary goals established under the 1990 Pollution Prevention Act. Of the 31 programmes administered in the US, 14 target the manufacturing and energy sectors where chemical manufacturers and distributors are in the greatest number, followed by electronics and computer manufacturers. The 33/50 Program is one of the success stories of the voluntary partnership programmes established between US EPA and industries. The overall goals have been to reduce national pollution releases and off-site transfers of 17 priority chemicals and to encourage pollution prevention. The specific goal was to reduce releases and transfers of the 17 chemicals by 33% by the end of 1992 and 50% by the end of 1995. Both goals were reached one year ahead of schedule. The 17 priority chemicals were chosen on the basis of three criteria, *i.e.* common industrial use, concerns for toxicity and environmental effects, and opportunities for pollution prevention.

In Canada, the ARET Program (Accelerated Reduction/Elimination of Toxics) was launched in 1994 to reduce releases of 30 persistent, bioaccumulative and toxic (PBT) substances by 90% and to reduce releases of a further 87 toxic substances by 50% from base year levels to the year 2000 (ARET, 2000). ARET is a multi-stakeholder pollution prevention and abatement initiative involving industry, health and professional organisations as well as governments across Canada. 316 facilities, representing 169 companies from 7 major industry sectors, have set reduction targets. The industry sectors are: chemical manufacturing (including specialities); aluminium; electric utilities; mining and smelting; oil, gas and petroleum products; pulp, paper and forest products; and steel. The participation rate among the sectors varies, but for the chemicals industry virtually all companies are taking part. Like the US EPA's 33/50 Program, participants in ARET use the programme to prioritise release reductions, determine appropriate reduction and elimination methods and to voluntarily set release reduction targets. As of 1998, participants had reduced annual toxic substance releases by 67% from base year levels and 136 facilities had met or exceeded their year 2000 targets. Since ARET is an open voluntary process, participants are responsible for the accuracy, consistency and validity of their reported releases, and this had led to criticism that the system lacks a credible verification mechanism. Another drawback is that although participation in ARET is high among the industry sectors whose associations are stakeholders, there has been difficulty in recruiting participants from outside these sectors. Environment Canada (1999) reports that releases of ARET substances by non-participating sectors are growing as those of participating sectors are falling, and that in 2000 their releases will equal those of ARET participants. Without the involvement of these non-participants, ARET's contribution to the reduction and elimination of toxic substance releases could become less and less consequential and improving participation will be a key consideration in any future programme.

Negotiated agreements are used extensively in Europe (particularly in the Netherlands and Germany) and Japan. In the EU a large number of negotiated agreements are with the most polluting industrial sectors (metals, chemicals and energy) with almost one-third being with the chemicals industry (OECD 1999c). They are used for all types of pollution, although the two main issues addressed are waste and climate. Negotiated agreements in the EU may or may not be legally-binding, although they are always legally-binding in the Netherlands where they constitute the key instrument of Dutch environmental policy.

In Denmark, an agreement signed between the Environment Minister and the Industry for Wood Preservation has led very quickly to the phase-out of arsenic and/or chrome products used as wood preservatives. Industry was encouraged to develop alternative fungicides, and in return, they were allowed to use the obsolete products for a transitional period until the alternatives could take over the market. The phase-out was initiated because arsenic compounds had caused cancer in humans and chromic compounds had caused effects on heredity and sensitisation in animals.

In Japan, the total number of negotiated agreements increased from 2000 in 1971 to 31,000 in 1996. Of the 31,000, 6% are with the chemicals industry. Negotiated agreements are the most popular approach used in Japan and they play a significant role in regulating industries at the local level, where they have replaced traditional regulation in many cases.

The voluntary industry commitment made in 1995 by the major global producers of brominated flame retardants to take certain risk management actions on three types of flame retardants is another example of a negotiated agreement. Unlike most such agreements, this one came about through negotiation with industry at the OECD level, rather than just with national governments. International agreement for action *via* a negotiated agreement was possible since OECD governments all agreed that measures should be taken. Attempts at OECD to take concerted action to reduce risks from exposure to lead were not so successful since there was no consensus at the beginning of negotiations on the risks posed.

Of the *unilateral initiatives* taken by the chemicals industry, the Responsible Care programme is the most important worldwide and is viewed by many as being one of the most important developments in the last 20 years. Responsible Care is the industry's voluntary commitment to continuous improvement in all aspects of health, safety and environmental performance, and to openness in communication about its activities and achievements. Initially developed in Canada in 1984, the Responsible Care programme was taken up by the International Council of Chemical Associations (ICCA) in 1991. The context of its creation was marked by a series of major accidents: Seveso in Italy, Bhopal in India, Love Canal in the US, and therefore came at a time when the chemicals industry needed to improve its public image.

An important component of Responsible Care is Product Stewardship whose purpose is to prevent injury to human health and damage to the environment through all stages of a product's lifecycle. It therefore includes the initial concept, design, research and development, manufacture, storage, distribution, applications, reasonable foreseeable use, recycling and disposal of a product. Product Stewardship requires co-operation among management, employees, contractors and customers and other parties involved in the supply chain, from raw material sourcing through to final disposal, to follow regulations and safe and environmentally sound practices.

Currently, national chemicals industry associations in 46 countries have committed themselves to Responsible Care. The schemes are in various stages of development but they cover 87% of global chemicals production by volume (ICCA, 1998). A Responsible Care Leadership Group has been established by ICCA to support the national chemical associations in their implementation of

Responsible Care and is ensuring the integrity of the programme at a global level. However, although there is a set of fundamental features agreed by the ICCA, each national association has its own set of guiding principles that define its approach. The content and implementation of the Responsible Care Programme can therefore vary among countries. In Canada, the Responsible Care Programme is characterised by relatively ambitious targets and strict control procedures with third party reporting. Companies not complying with the codes can be excluded from the national association, and legal sanctions are possible. In France, however, targets are less ambitious, monitoring is based on self-reporting and the only sanction is the exclusion from the national association, *i.e.* there is no influence on French court decisions (OECD, 1999c).

A recent interesting development is an agreement between the International Federation of Chemical, Energy, Mine and General Workers Unions and the ICCA for meaningful involvement of workers and their representatives in Responsible Care. This agreement demonstrates that voluntary industry initiatives can develop to a more inclusive level, with benefit to management, workers and the broader environment. Nevertheless, a key challenge for the industry will be to develop performance measurements for Responsible Care since stakeholders will want to know that progress is being made.

An example of a unilateral agreement at the individual company level is the May 2000 decision by 3M Corporation to voluntarily phase out perfluorooctanyl sulfonate (PFOS) chemistry by the end of the year. PFOS chemistry is used to manufacture a wide range of industrial, commercial and consumer applications. These include use as a component of soil and stain-resistant coatings for fabrics, leather, furniture and carpets; in fire-fighting foams; in floor polishes, cleaning products and as a surfactant. The phase-out is the result of a successful product stewardship effort between 3M and the US EPA. PFOS chemicals are very persistent in the environment, have a strong tendency to accumulate in human and animal tissues, and could potentially pose a risk to human health and the environment over the long term.

ANNEX 20:
International conventions involving chemical substances

Convention on Long-range Transboundary Air Pollution (LRTAP)

This Convention entered into force in 1983 to combat acidification of Scandinavian lakes caused by sulphur emissions in continental Europe. It has since been extended to cover other issues such as the control of nitrogen oxides, volatile organic compounds, heavy metals and POPs. LRTAP lays down general principles of international co-operation for air pollution abatement. There are 46 countries that are Parties to the convention - 45 European countries and the US and Canada.

Montreal Protocol

A particularly successful example of international co-operation is the phasing out - through the Montreal Protocol - of the production and consumption of chemicals that deplete ozone in the stratosphere. The Protocol came into force in 1989 with the objective to eliminate ozone-depleting substances (ODS) to agreed timetables.

Basel Convention

The Basel Convention controls transboundary movements of hazardous waste and their disposal. It entered into force in 1992 and there are 134 Parties from all regions of the world. The US is not a Party.

OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic

Its objective is to eliminate releases of persistent, toxic and bioaccumulating substances to the North-East Atlantic by 2020. The OSPAR Convention came into force in March 1998, and 15 countries, as well as the EU, are Parties to it.

HELCOM Convention on the Protection of the Marine Environment of the Baltic Sea Area

Its objective is the same as OSPAR's. Contracting parties are Sweden, Denmark, Germany, Poland, Lithuania, Latvia, Estonia, Russia, Finland and the European Union.

Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

Operating since 1989 as a voluntary code, the PIC Procedure helps participating countries learn more about the characteristics of potentially hazardous chemicals that may enter their territory, initiates a decision-making process by these countries on the future import of the chemicals and facilitates the dissemination of this decision to other countries. When the Convention comes into force after it has been ratified by 50 countries, the PIC procedure will become legally-binding, *i.e.* if a chemical has been put on an agreed list, exporters will be legally-bound to respect the decision of countries that say they do not want to import it. Currently there are 22 pesticides and 5 industrial chemicals on the list, but it is expected that many more will be added in the future. The Convention should help limit the use of hazardous chemicals to situations where they are absolutely necessary, ensure that they can be used safely and help prevent new chemical safety problems.

Convention on Persistent Organic Pollutants

The POPs Convention is expected to be adopted by spring 2001. Its goal will be to reduce and/or eliminate emissions, discharges and, where appropriate, the manufacture and use of POPs. Currently there are 12 named POPs, but it is expected that others will be identified in the future. An interesting issue involved in the negotiations has been the dichotomy between the desire for a global phase-out of DDT due to its environmental effects, *versus* the need of developing countries to use DDT as a cost-effective means for controlling malaria. Using DDT to control malaria mosquitoes would be exempt from the treaty subject to periodic review.

ANNEX 21: How environmental regulations are appraised in OECD countries

Type of Appraisal Applied to Environmental Regulations by Country				
Country	**Cost Only**	**Cost-Effectiveness**	**CBA**	**Comment**
Australia			•	Applied throughout Commonwealth and certain states to bills and lower-level rules where costs to business may be high
Austria	•			Recommended for bills
Canada	•	•	•	Regulatory Impact Analysis Statements accompany draft and final regulations summarising any analysis which may be in the form of a Business Impact Test, Regulatory Cost Account Protocol or other equivalent analysis
Denmark			•	Potentially within general impact analysis required for new legal proposals
European Union			•	Required for each proposed regulatory action
Finland	•			Applied to bills and lower-level rules
Hungary			•	Economic evaluation of proposed environmental regulations required
Italy	•			Cost-output analysis' used
Japan				General impact analysis applied as required
Mexico		•	•	Applied to business-related' procedures
Netherlands	•			Effects of new regulation on industry/trade
New Zealand	•			Applied to draft laws from Cabinet
Norway		•	•	Economic impact assessment of proposed regulations may be CBA. Cost-effectiveness of Environmental policies
Portugal	•			Applied to certain bills
Spain	•			Assessing the effect of regulatory proposals on public budget
Turkey				General impact analysis for bills
United Kingdom	•		•	Costs of new and amended regulations to business assessed. CBA may be required in specific cases
United States		•	•	Regulatory Flexibility Analyses and CBAs required for actions subject to Executive Order 12866 when not specifically prohibited by enabling statute

Source: Based on data presented in OECD (1997c); *Reforming Environmental Regulation in OECD Countries*, OECD, Paris
CBA: Cost Benefit Analysis

ANNEX 22:
Modelling framework used for the Reference Scenario and Policy Simulations

(Excerpt from Annex 2 of the *OECD Environmental Outlook*; OECD, 2001a)

1. Introduction

The Reference Scenario and the policy simulations described in this *Outlook* were made using a global general equilibrium model (JOBS) which was developed by OECD's Development Centre.[27] Results from these simulations – *e.g.* concerning developments in value added and relative prices – were fed into the PoleStar framework, developed by the Stockholm Environment Institute Boston. PoleStar then enabled us to calculate a number of environmental impacts, as described in the chapters of this *Outlook*. This Annex provides a brief description of the assumptions used in the Reference Scenario to 2020 and the policy simulations, and explains the structure of the JOBS model and the PoleStar system.

2. Underlying assumptions

2.1 Population

The growth of total population and labour supply is exogenous in all the simulations presented in this *Outlook*, and the assumptions used are presented in Chapter 2. The assumptions are based on the medium fertility version of the 1998 UN population projections. The labour force in each region is assumed to constitute a fixed portion of the population in the age group 15-64 years. This means that – on balance – no major net changes are assumed to take place in factors such as the rate of unemployment, male and female labour force participation rates, etc.

27. The JOBS model was further developed from 1998 to 2000 for the purposes of this exercise. Papers describing its development were discussed in meetings of the OECD Working Party on Economic and Environmental Policy Integration during this period, including "Macroeconomic Model Simulations: Assumptions in a "Baseline Scenario" [ENV/EPOC/GEEI(99)8], "Macroeconomic Model Simulations: Some Policy Scenarios" [ENV/EPOC/GEEI(99)14], and "Consumption and the Environment: Exploring the Linkages with Economic Globalisation"[ENV/EPOC/GEEI(99)2/REV2]. Based on the discussion in these meetings and other comments, a number of the assumptions in the model were refined for the Reference Scenario and policy shocks presented in this *Outlook*. This Annex describes the final model assumptions and structure used.

2.2 GDP in the Reference Scenario

A specific development of total GDP[28] is assumed for each region up until 2020 in the Reference Scenario, cf. Figure 4.1 in Chapter 4 and Table A1. The assumptions used in the Reference Scenario are, as far as possible, the same as those used in the climate change policy analyses done by the OECD on the "GREEN" model, cf. Burniaux (2000). However, due to *inter alia* some differences in the regional groupings used in the GREEN model and the JOBS model, the assumptions are not identical. In any case, it is underlined that the growth assumptions do not represent prognoses, merely a starting point for exploring possible impacts of changes in policy assumptions, etc.

While the GDP growth rates are exogenous in the Reference Scenario, capital productivity is endogenous. Furthermore, while the supply of labour is exogenous, the labour productivity parameter (which is uniform across sectors) is calibrated so as to ensure that the ratio of capital (in efficiency units) to labour (in efficiency units) is constant over the simulation period.

In the policy shocks, the growth rates of capital and labour productivity which were calculated endogenously in the Reference Scenario, are used as exogenous assumptions. In these simulations, changes in real GDP and in capital-labour ratios are endogenous.

Table A1: Historical and assumed levels of real GDP, 1995 US$ billion

	1980	1995	2000	2005	2010	2015	2020
NFT	4,960	7,347	8,476	9,590	10,588	11,463	12,410
WEU	5,861	8,071	9,087	10,331	11,129	11,813	12,539
CEU	370	449	536	668	817	975	1,163
JPK	2,980	5,084	5,277	5,942	6,528	6,998	7,539
ANZ	232	372	432	503	561	611	667
FSU	626	447	394	468	583	710	863
CHN	150	653	942	1,237	1,578	1,995	2,522
EAS	280	784	882	1,116	1,410	1,757	2,159
SOA	153	359	466	578	711	873	1,072
MEA	281	463	512	570	636	709	790
LAT	893	1,252	1,365	1,591	1,835	2,107	2,419
ARW	452	646	740	866	1,004	1,164	1,350
OECD	14,403	21,323	23,808	27,033	29,623	31,860	34,318
Non-OECD	2,834	4,604	5,302	6,426	7,757	9,315	11,175
World	17,237	25,927	29,109	33,459	37,380	41,175	45,493

Key to acronyms in table A2

3. The JOBS model

3.1 Basic characteristics

JOBS is a neo-classical general equilibrium model that was initially constructed to assess the economic impacts of globalisation on individual regions of the world. JOBS is a version of the LINKAGE model, used in the OECD Linkages II project, which *inter alia* resulted in the publication "The World in 2020: Towards a New Global Age" (OECD, 1997b). The LINKAGE model was in turn

28. While the total GDP in each region is given exogenously, the distribution of this total production among the 26 sectors in each region of the model is determined endogenously, reflecting *inter alia* the relative producer prices and the relevant substitution elasticities.

derived from the GREEN model that has been used in a series of analyses of policies to combat climate change.[29]

JOBS is designed for the analysis of dynamic scenarios, which are solved as a sequence of static equilibria. The periods are linked by exogenous population and labour supply growth, capital accumulation and productivity developments. For this *Outlook*, a Reference Scenario was developed, and impacts of a number of policy shocks were compared to this. The simulations were based on data from Version 4.0 of the Global Trade Analysis Project (GTAP) database, developed by Purdue University[30], with 1995 as the base year. This database contains consistent data for 50 sectors and 45 regions. The JOBS model is implemented with GAMS software, and includes a flexible aggregation facility which may be set by the user up to the maximum dimensions of the GTAP data set. For purposes of the *Environmental Outlook*, a Reference Scenario was developed and policy simulations were undertaken for 12 geographical regions and 26 economic sectors as described in Tables A2 and A3 respectively.

Figure A1 describes the production structure used in JOBS. The inputs used to produce a given output have been divided into several distinct components, namely non-energy intermediate inputs, energy intermediate inputs, one category of labour, one type of capital, land (in agriculture sectors only) and a natural resource factor used in the Forestry, Fisheries, Minerals, Coal, CrudeOil and NaturGas sectors. A nested set of CES functions (Constant Elasticity of Substitution) was used to emulate the different degrees of substitution and complementarity between the various inputs, and a brief description of the substitution elasticities[31] (the σ's in the shaded boxes) used is included in the figure.

At the top of Figure A1, an aggregate bundle of non-energy intermediate inputs is combined with a value added and energy bundle, with a very low elasticity of substitution (0.05). Hence, these two bundles will always be used in almost fixed proportions. The aggregate non-energy intermediate bundle is decomposed into demand for individual intermediate goods, with no substitution possibility between the different goods. In many cases, this is a reasonable approximation, as the substitution possibilities in reality are often limited. However, in some cases, this technical assumption imposes unrealistic limitations on the substitutions that can take place when relative prices change, *e.g.* as a result of increases in taxes on certain products.[32] This should be borne in mind when interpreting the results of some of the policy shocks simulated.

29. See, for instance, Burniaux (2000).

30. For further details, see http://www.agecon.purdue.edu/gtap. Version 5.0 of GTAP now includes an extension and update of the database compared to Version 4.0. This version was, however, not available at the time the simulations for this publication were made.

31. A substitution elasticity describes the change in the relative use of two factors if the relative price between these factors changes by one factor. A substitution elasticity equal to zero means that two factors are always used in fixed proportions. A high substitution elasticity means that a small change in relative prices will cause a significant change in the composition of inputs used.

32. One could, for example, expect an increase in the use of *Wood products* as input in the *Construction* sector, if the relative price of *Iron and steel*, or *Non-ferrous metals*, increased. In the current version of JOBS, such a substitution is not possible.

Table A2

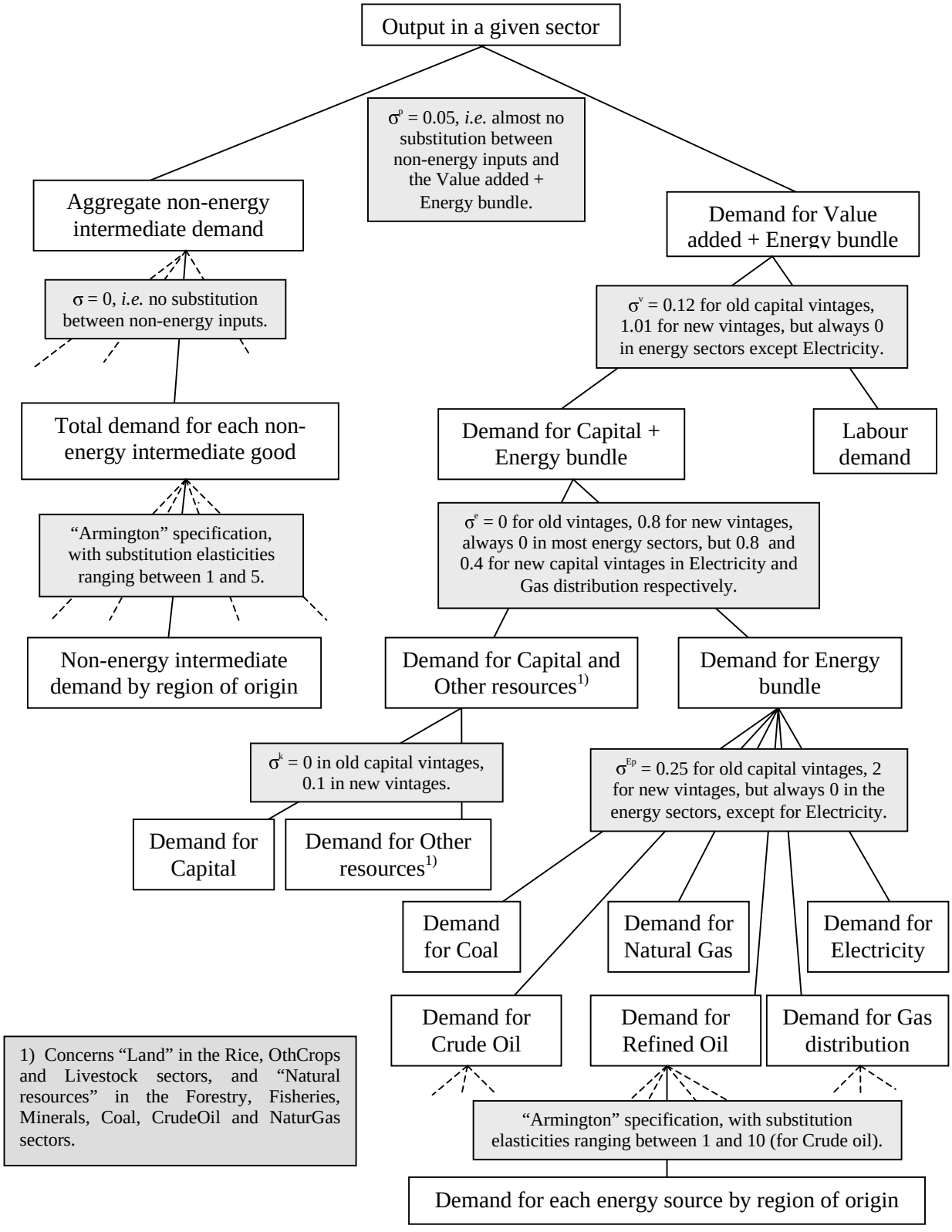
Regions used in the model simulations		
	Region name	**Countries**
NFT	Canada, Mexico & United States	Canada, Mexico and United States
WEU	Western Europe	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Liechtenstein, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and Iceland
CEU	Central & Eastern Europe	Czech Republic, Hungary, Poland, Slovakia and Turkey (OECD members), Romania and Bulgaria
JPK	Japan & Korea	Japan and Korea
ANZ	Australia & New Zealand	Australia and New Zealand
FSU	Former Soviet Union	Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan
CHN	China	China (including Hong Kong)
EAS	East Asia	Indonesia, Malaysia, Philippines, Singapore, Taiwan, Thailand and Vietnam
SOA	South Asia	Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka
MEA	Middle East	Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates and Yemen
LAT	Latin America	Anguilla, Antigua & Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, British Virgin Islands, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St.Kitts & Nevis, St.Vincent & Grenadine, Suriname, Trinidad & Tobago, Uruguay and Venezuela
ARW	Africa & Rest of the World	Afghanistan, Albania, Algeria, Angola, Benin, Bosnia and Herzegovina, Botswana, Brunei, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, Congo, Croatia, Cyprus, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Ivory Coast, Kenya, North Korea, Laos, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Malta, Mauritania, Mauritius, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Niger, Nigeria, Papua New Guinea, Rwanda, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, The former Yugoslav Republic of Macedonia, Togo, Tunisia, Uganda, Yugoslavia, Zaire, Zambia and Zimbabwe

Table A3

Sectors used in the JOBS model	
Name	**Content**
Rice	Paddy Rice
OthCrops	Wheat, cereal grains n.e.s., vegetables, fruit, nuts, oil seeds, sugar cane, sugar beet, plant-based fibers, crops n.e.s.
Livestock	Live animals, Raw milk, wool, silk-worm cocoons, etc.
Fisheries	Fisheries
Forestry	Forestry
Minerals	Minerals
Coal	Coal
CrudeOil	Crude oil
NaturGas	Natural gas extraction
RefOil	Petroleum, coal products
GasDistr	Gas manufacture and distribution
Elect	Electricity generation and distribution
Meat	Meat from all types of animals
OthFood	Vegetable oils and fats, dairy products, processed rice, sugar, food products n.e.s., beverages and tobacco.
Chemicals	Chemical, rubber, plastic products
I_S	Iron and steel
NonFer	Non-ferrous metals
WoodProd	Wood products
PPP	Pulp Paper Publishing
MotorVehi	Motor vehicle manufacturing including parts
OthManu	Textiles, wearing apparel, leather products, metal products, transport equipment n.e.s., electronic equipment, machinery and equipment n.e.s., manufactures n.e.s..
Construc	Construction
Water	Water supply
TradeTran	Trade and transport services
Service	Finance, business, recreational services, public administration, defense, education, health.
Dwellings	Dwellings

Note: n.e.s. = “not elsewhere specified”

Figure A1: Nested structure of production in the JOBS model



In the agriculture sectors JOBS does, however, allow additional substitution possibilities: in the Rice and OthCrops sectors, it is possible to substitute between the use of Chemicals inputs and the capital, energy and land bundle, and in the Livestock sector, one can substitute between the use of Land and the use of purchased feedstock. Hence, for example a tax increase on chemicals used in Rice production can lead to a substitution away from the use of such chemicals towards more use of capital, land or energy.

It is important to note that JOBS distinguishes between two vintages of capital – old and new (the latter being largely equal to each year's investment) – with the substitution possibilities (*e.g.* across energy sources) being higher concerning new capital than for old. New capital is perfectly mobile between sectors, and its allocation insures a uniform rate of return in each sector. The rate of return to old capital in expanding sectors is also equal to the economy-wide rate of return on new capital. Declining sectors are assumed to release capital, which is added to the stock of new capital in a given year. The rate of return on old capital in declining sectors will be lower than the return achieved in other sectors, and it is determined by sector-specific supply and demand conditions.

The model does not include an investment function which relates the overall level of investment to the expected rate of return. Indeed, there is no forward-looking investment behaviour incorporated in the model. Instead, the value of investment in each year and region is equal to the value of aggregate saving in the region. Aggregate saving, in turn, is derived from household behaviour.

Household consumption demand is modelled through the use of a so-called "extended linear expenditure system" (ELES). This consumption demand includes a demand for future goods, represented through the demand for savings, which in turn is determined as a residual, as the difference between household disposable income and current expenditures. The demand for each category of goods and services consists of two components: a population-adjusted subsistence minimum and a component reflecting *inter alia* the relative prices of the different categories.[33]

The volume of government expenditure is assumed to be a constant share of real GDP at market prices. Real government saving is exogenous, thus the government is assumed to have a target for the net fiscal position of the public budget. The direct tax rate on household income is endogenous, and the household tax schedule shifts over time to accommodate the given level of real government saving.

One important aspect of the JOBS model is that domestically produced products and imported products of the same type are assumed to be imperfect substitutes, which *inter alia* implies that their prices may differ in a given market. The elasticities describing the degree of substitutability between domestic and foreign products are called "Armington elasticities". The higher the Armington elasticity, the easier it is for users to substitute between domestic and foreign products of a particular type.[34] In the simulations made for this *Outlook*, the Armington elasticities are assumed to be equal

33. Income elasticity estimates needed to calibrate the ELES system are taken from the GTAP database. A problem with an ELES demand system is that all income elasticities over time converge towards 1, meaning that the budget shares of each product category become constant. That would certainly be wrong for most goods. To alleviate this problem, the demand parameters are re-calibrated between each period, so that the income elasticities remain more or less constant over time.

34. The Armington elasticities assumed in the Reference Scenario are highest for commodity-based sectors such as Oil (10.0), Coal, Refined oil, Iron and Steel (5.0), and lowest (1.0) for service sectors such as Electricity, Gas distribution and Dwellings. Their empirical foundation is not strong. However, sensitivity analyses indicate that, for instance, a doubling of all of these elasticities does not alter the results of the simulations fundamentally. It is technically possible, and it would in principle be of interest, to vary the Armington elasticities between regions and/or between end-users within each region. This

between all regions, and between all end-users within each region, but they vary between different sectors. Total demand for a given type of product within a region is called "Armington demand". This total demand is split into a demand for imported and domestically produced products via the Armington elasticities.

One implication of the "Armington specification" of international trade is that each region faces a downward-sloping demand curve for its exports. The more their production is to increase, the lower their relative export prices need to be. Hence, regions that expand their production more rapidly than other regions will tend to experience a term-of-trade loss, *i.e.* their export prices will decrease compared to the prices of their imports.

4. The PoleStar framework

The PoleStar framework was developed by Stockholm Environment Institute Boston to describe developments for a number of environmental parameters. The framework has previously been used in a number of scenario analyses, for instance in the publication "*Bending the Curve: Toward Global Sustainability*" (Raskin *et al.*, 1998). A number of modifications have been made to the framework for this *Outlook*, so that the results from the JOBS simulations could be used as drivers for the environmental impacts simulated in PoleStar. This section provides an overview of the assumptions used in the present analysis.

4.1 Fuel demand

JOBS estimates economic transfers between different economic sectors. These transfers include those between energy-producing and energy-consuming sectors, which – for the purposes of this analysis – are taken as proxies for the transfer of fuel. The fuel-producing sectors tracked in JOBS are Coal, Crude oil Natural gas, Refined oil and Electricity. Within PoleStar, trends in household biomass consumption and district heat are also estimated. Biomass consumption is estimated based on a cross-sectional analysis, using International Energy Agency (IEA) energy data, of *per capita* biomass consumption against income. District heat consumption *per capita* is held at base year levels in all regions.

The JOBS output used in the PoleStar analysis is expressed in nominal US dollar terms. Because values are in nominal terms, trends in raw output do not correspond directly to physical flows. However, JOBS also estimates prices for goods paid for by different consuming sectors, allowing an estimate of transfers in real terms (after correcting for changes in efficiency of resource use in consuming sectors). As a result, using JOBS it is possible to estimate trends in physical fuel consumption, as indices calculated relative to consumption levels in the base year.

Energy use by the energy sectors is also estimated. Three energy transformation sectors are included: oil refining, electricity generation and district heat. Of these, two are treated in JOBS: oil refining and electricity generation. Furthermore, within electricity generation a subset of feedstock fuels is considered: petroleum, coal and natural gas. Other sources of electricity are omitted: nuclear power, hydroelectric and renewables. For the Reference Scenario, trends in refining activity and use of petroleum, coal and natural gas are derived from JOBS. Real output from the oil refining sector drives refinery production in PoleStar, while real transfers from the refining, coal production and natural gas

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would, however, complicate the solving of the model considerably, and would require assumptions to be made regarding a very large number of parameters, with little empirical foundation.

distribution sectors to the electricity generation sectors are used to generate trends in use of these fuels for electricity production. Trends in electricity generation from nuclear, hydroelectric and renewable plants are based on separate analyses from IEA (IEA, 2000b). Fuel shares for district heat production are held at base year levels. Trends in real supplies from energy sectors to other sectors were applied to base year consumption estimates based on IEA energy statistics (IEA, 1999a).

4.2 CO_2 emissions

Carbon emissions are estimated from energy consumption data and emissions factors based on IPCC (1995). Carbon dioxide emissions are estimated for fossil fuel combustion and feedstock use. Carbon emission intensities are applied to fuel consumption in all sectors. Industrial process emissions are not included.

4.3 SO_x emissions

Data on sulphur emissions for the base year are based on Posch *et al.* (1996) and Kuylenstierna (1998). Sulphur emission intensities are applied to fuel consumption in all sectors. Additionally, industrial process emissions for the Nonferrous Metals sector are included.

In the industrial sector, a gradual reduction of sulphur emission factors for fuel combustion and process emissions is assumed in most regions in the Reference Scenario, reflecting the fact that these can be affected by end-of-pipe cleaning technologies and fuel switching. In all regions, emission coefficients converge linearly to a value of 0.65 for coal, 0 for crude oil (used as a feedstock in the Chemical sector) and 0.0005 for petroleum, all other fuels staying at the base year value. The values would converge completely in 2050; otherwise they change linearly with time. Some regions start out with emission coefficients below these target values. In that case, the emission coefficient remains at the base year value.

ANNEX 23:
Third Session of the Intergovernmental Forum on Chemical Safety
(Bahía, Brazil; 15 – 20 October 2000)

Priorities for Action Beyond 2000

1. The Intergovernmental Forum on Chemical Safety (IFCS or Forum) is a non-institutional arrangement whereby representatives from governments and non-governmental and intergovernmental organizations consider and provide analysis and advice on the environmentally sound management and reduction of risks from chemicals. Where appropriate, IFCS makes recommendations to other organizations that have mandates to implement activities to improve the management of chemicals.

2. Recommendations for *Priorities for Action beyond 2000* follow. These recommendations deal with:

- Priorities for Action by governments;
- Work by which international bodies may develop effective tools for use by governments; and
- Ways in which stakeholders may demonstrate their commitment to chemical safety.

The Forum actively supports cooperation between international organizations and governments, and the implementation of international agreements nationally. It also encourages cooperation between countries, particularly within regions and sub-regions of the world.

The Forum encourages international organizations participating in the Inter-Organization Programme for the Sound Management of Chemicals (IOMC) to continue their efforts to enhance coordination of their activities aimed at strengthening capacities of developing countries and countries with economies in transition and in the framework of an explicit demand-driven process to these countries for strengthening and integrating their chemicals management.

3. The efficient coordination of chemical safety endeavours by all participatory and concerned sectors is a prerequisite for successful results at the national level. The active participation of employers and workers, the mobilization of the non-governmental sector, and the strengthening of community 'right to know', are important facets in increasing chemical safety. Manufacturers, importers, formulators and industrial users should have the main but differentiated responsibility for generating and assessing data, as well as providing adequate and reliable information to users, governments and the public on the safety and safe use of their products for that part of the life cycle to which they contribute. Public authorities are responsible for establishing the general framework for the risk assessment procedures and controls.

4. Sound management of chemicals depends on a variety of factors including research, training, information and communications, implementing control measures, capacity building, financial and

technical assistance, and the transfer of technology to developing countries and countries with economies in transition.

It is recommended that additional educational programs and training courses be arranged at national and regional levels in developing countries and countries with economies in transition, to provide a core of trained technical staff and policymakers. Specific efforts should be made to improve the coordination of activities in education, training and technical assistance.

5. Control of chemicals and pollution control initiatives should be closely integrated and the precautionary approach, as outlined in principle 15 of the Rio Declaration, should be applied[35]. The full range of risk reduction options should be considered, including encouraging, in particular, replacing more dangerous chemicals with less dangerous ones or using alternative processes.

6. To protect the health of workers, special attention should be paid to occupational health and safety concerns caused by chemicals. To protect the health of the general public, chemical safety issues regarding susceptible groups (e.g. persons of fertile age, pregnant women, foetuses, children, the sick and elderly) need to be clearly addressed in the assessment and management of risks.

Public interest non-governmental organizations have a valuable role as conduits of information, being well positioned to disseminate industry and government information to their communities and also to transfer the community concerns about toxic substances back to regulators and policy makers.

7. It is recognized that technical and financial assistance and technology transfer to developing countries and countries with economies in transition is important to accomplish the IFCS "Priorities for Action beyond 2000".

Whilst recognizing that there are established mechanisms for bilateral and multilateral assistance to developing countries and countries with economies in transition, there is a strong need to strengthen and broaden these arrangements in order to achieve effective management of chemical safety. Technical and financial assistance should be provided in a non-discriminatory way.

8. The order in which the following recommendations are presented is not intended to suggest their degree of importance.

Programme Area A:

Expanding and accelerating international assessment of chemical risks

1. Common principles for harmonized approaches for performing and reporting health and environmental risk assessments should be developed as soon as possible. Such principles must be internationally accepted, thus permitting the full use of risk assessments performed by international and national bodies.

By 2004, the International Programme on Chemical Safety (IPCS) and the Inter-Organization Programme for the Sound Management of Chemicals (IOMC) participating organizations should have ensured that recommendations for common principles for harmonized approaches should be available for terminology, cancer, and

35. Some countries preferred the word "*considered*", the majority of participants adopted the word "*applied*".

reproductive and developmental toxicology. Common principles for the approach to other specific toxicological endpoints, such as immunotoxicology, endocrine disruption, and ecotoxicology, should be adopted wherever possible.

2. Hazard evaluation (i.e. the first step of risk assessment) should be carried out in accordance with the requirements of harmonized health and environmental risk assessments, including internationally recommended methodology, ensuring transparency and openness. These evaluations should be undertaken with the support of the participating organizations of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC). New alternative test methods which enable the use of fewer laboratory animals should be developed, standardized and validated.

Hazard evaluations should be carried out in accordance with internationally recommended methodologies and in an open and transparent manner. In addition to ongoing national, regional and international evaluation programmes, through the industry initiative an additional 1000 chemicals hazard assessments will be provided by 2004, and the resulting information will be made available to the public in a timely manner.

The goal of risk assessment is to estimate the likelihood of an adverse effect on humans, other species and/or on ecological systems. This requires knowledge of exposure and of the susceptibility of species or systems likely to be impacted; this can vary from one region to another. Test methods and data have been largely developed that are most relevant to the more temperate climatic regions.

The cooperation of developing countries and countries with economies in transition should be sought to ensure that all relevant data, including exposure data, required to assess human and environmental risks are developed and assessed.

3. For all chemicals in commerce, appropriate data detailing the inherent hazards of those chemicals should be made available to the public. Highest priority should be given to hazard information for those chemicals that have greatest potential for substantial exposures.

To implement this principle, the Forum Standing Committee should develop a proposal for an additional *Priority for Action* to be discussed at Forum IV. This *Priority for Action* should address:

- **The role of industry in generating and assessing data;**
- **The role of industry and governments in making available, and easily accessible, to the public the results of tests and their interpretation leading to conclusions about the degree of hazard or risk involved;**
- **The desirability of reducing the use of animals for toxicity testing where other methods, that may give a similar assurance of safety, are available; and**
- **Possible approaches for ensuring that relevant data become available to the public and authorities in the shortest possible time-frame, considering incentives and/or restrictions that might serve this purpose.**

Programme Area B:

Harmonization of classification and labelling of chemicals

1. The Forum recognizes that global harmonization of the classification and labelling of chemicals greatly increases the protection of human health and our environment, as well as facilitating the flow of trade. Ongoing work will soon result in the completion of a globally harmonized system for the classification and labelling of chemicals. This system will include classification criteria, related labelling systems, and guidelines for material safety data sheets, which comprise the hazard communications elements of the system. The Forum should provide mechanisms for consultation and participation of all countries in the development process of a harmonized system for classification and labelling.

The Globally Harmonized System (GHS) for the Classification and Labelling of Chemicals should be agreed to by the Inter-Organization Programme for the Sound Management of Chemicals coordinating group for the harmonization of chemical classification systems and fully adopted by the Economic and Social Council of the United Nations prior to Forum IV.

Guidance and other tools necessary for the implementation of the GHS should be made available to interested parties prior to Forum IV.

All countries are encouraged to implement the GHS as soon as possible with a view to have the system fully operational by 2008.

All countries, subject to their capacities and capabilities, should take account of the development of the GHS in any proposed changes to existing systems for classification and labelling, and in the implementation and enforcement of their chemicals legislation.

Programme Area C:

Information exchange on toxic chemicals and chemical risks

1. All governments should be encouraged to identify and/or to establish arrangements for the timely exchange of information on chemicals. Through the effective operation of such arrangements, barriers to information exchange would be more easily overcome. Relevant information could then be communicated in a timely and appropriate manner and, where appropriate, in at least one of the six official languages of the United Nations in addition to the required language(s), to all relevant parties.

The Inter-Organization Programme for the Sound Management of Chemicals (IOMC) participating organizations should take the lead for coordinating fundraising and implementation efforts to ensure that all government officials from developing countries and countries with economies in transition responsible for chemicals management have access to Internet and training on its use.

This type of arrangement may be described in a National Action Plan. It should include input from a broad range of stakeholders including all levels of government, non-governmental organizations, and the general public within the country. The Inter-Organization Programme for the Sound Management of Chemicals (IOMC) participating organizations, and their regional structures, where relevant, should consider facilitating information exchange both within and between countries by issuing general guidance.

IFCS is called upon to support the initiative to eliminate 'barriers to information exchange for the sound management of chemicals' in order to enhance communication among national, sub-regional, regional and international stakeholders.

> **By 2005, at least five countries in each region, and by 2010, most countries should have fully operational arrangements in place for the exchange of information on hazardous chemicals.**

2. The Forum recognizes the role of the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade for information exchange on toxic chemicals.

> **All countries are encouraged to ratify or accede to the Rotterdam Convention with a view to its entry into force as soon as possible, preferably by Forum IV. To this end, all efforts must be made to ensure that the necessary procedures are put into place so that countries can successfully implement the Convention in a prompt manner.**

3. The Forum recognizes the importance of providing all relevant parties with safety information on the hazardous properties of chemicals in an easy-to-access, easy-to-read and easy-to-understand format. All countries are urged to establish mechanisms to this effect using procedures that are consistent with those concerning the safety data sheets of the 1990 International Labour Organization (ILO) Chemicals Convention (No.170). Industry should communicate with the public, especially by dissemination of information on hazards connected to chemical production.

> **By 2004, most countries should have procedures in place to ensure that any hazardous material put into circulation is accompanied, at a minimum, by appropriate and reliable safety information that is easy to access, read, and understand, consistent with the safety data sheets of the 1990 International Labour Organization Chemical Convention (No. 170) and taking into account the development of the Globally Harmonized System for the Classification and Labelling of Chemicals as it develops.**

The Forum recognizes the need to ensure that essential health, safety and environmental information is not withheld under confidentiality restrictions.

Programme Area D:

Establishment of risk reduction programmes

1. To protect human health and the environment (including surface and ground water), countries should establish ecologically sound and integrated strategies for the management of pests and, where appropriate, vectors for communicable diseases.

> **By 2004, most countries should have in place integrated and ecologically sound pest management strategies. Where appropriate, specific strategies for control of vectors (for communicable diseases) should be established.**

2. The identification, neutralization, and safe disposal of obsolete stocks of pesticides and other chemicals (especially polychlorinated biphenyls (PCBs) must be urgently facilitated by provision of technical and financial assistance particularly in developing countries and countries with economies in transition. As well, future stockpiling of other obsolete pesticides and chemicals must be prevented.

With respect to the final disposition of chemicals, the Forum and Inter-Organization Programme for the Sound Management of Chemicals (IOMC) participating organizations should promote the use of techniques that minimize risks, *i.e.* less polluting and safer technologies.

By 2004, countries should have established relevant action plans, and at least two countries in each region should have commenced implementation of their National Action Plans with respect to disposal, considering the outcomes of relevant international agreements.

3. Special attention should be paid to persistent and bio-accumulating toxic chemicals.

Work on a global convention on persistent organic pollutants (POPs) should continue with a view to reach agreement, by the end of 2000, on a strong and effective convention that will encourage countries to:

- **Adopt it at the Conference of Plenipotentiaries, to be held in Stockholm in May, 2001;**

- **Ratify it with a view to its entry into force as soon as possible, preferably by 2004.**

The Forum Standing Committee is requested to invite countries and regions to present at Forum IV risk reduction initiatives on other chemicals of major concern.

4. Major industrial accidents must be prevented. National systems for emergency preparedness and response should be developed in all countries. Such systems would include strategies for educating and training personnel. In developing such mechanisms, significant international guidance can be found in documents prepared by the Inter-Organization Programme for the Sound Management of Chemicals (IOMC) participating organizations[36].

By 2002, 70 or more countries should have implemented systems aimed at preventing major industrial accidents and for emergency preparedness and response. These systems should be in accordance with international principles.

5. Poisoning of pesticide users, especially agricultural workers and small farmers in developing countries and countries with economies in transition, must be prevented. The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade will address aspects of this problem. However, in order to more comprehensively address the problem of acutely toxic pesticides, the Forum:

Requests the Forum Standing Committee to provide initial input on the extent of the problem of acutely toxic pesticides, and provide guidance for sound risk management and reduction, including options for phasing out where appropriate, and report to Forum IV.

Urges countries to apply the existing mechanisms under the Rotterdam Convention to notify the Secretariat for the Rotterdam Convention on severely hazardous pesticide

36. Such as the 1993 ILO Convention (No. 174) on the Prevention of Major Industrial Accidents, the OECD Guiding Principles on Accident Preparedness and Response, the programme on Awareness and Preparedness for Emergencies at Local Level (APELL), the 1991 ILO Code of Practice on the Prevention of Major Industrial Accidents, and the 1999 IPCS Public Health and Chemical Incidents guidance document. In addition guidance exists in the United Nations Economic Commission for Europe (UN/ECE) Convention on Trans-boundary Effects of Industrial Accidents.

formulations under conditions of use in developing countries and countries with economies in transition, and request the Secretariat for the Rotterdam Convention to report on progress to Forum IV.

6. IFCS should support and encourage the Food and Agriculture Organization (FAO) in its efforts to revise the International Code of Conduct on the Distribution and Use of Pesticides at its Biennial Conference in November 2001.

Following adoption of the revised Code, IFCS should (a) support and encourage governments to play an active role in its observance; and (b) work with the FAO and all main stakeholders to enable them to play an active role in monitoring progress on implementation of the Code.

7. Poison centres, providing toxicological information and advice, should be established and strengthened, with relevant clinical and analytical toxicological facilities developed according to the needs identified and resources available at the level of each country. In developing these facilities, relevant international guidance can be found in the International Programme on Chemical Safety (IPCS) Guidelines for Poisons Control published by the World Health Organization (WHO).

By 2002, poison centres should have been established in 30 or more countries that do not yet have such centres, and further strengthened in 70 or more countries where they already exist. Extensive progress should have been made on national systems for collection of harmonized data, including categorization by, for example, type of poisoning, chemical identity, structure, use or function.

8. Pollutant Release and Transfer Registers (PRTRs)/emission inventories are recognized in Chapter 19 of Agenda 21 as an important tool to raise public awareness about potential chemical risks and as an effective environmental management tool to stimulate chemical risk reduction. Although PRTRs are designed to be country-specific, there are commonalties between national systems. Common characteristics of many successful PRTR programmes include: a listing of pollutants; environmental multi-media and/or integrated reporting of releases and transfers (i.e. to air, water, and land); reporting of data by source; reporting of data periodically (normally annually); and making data and information available to the public.

By 2004, at least two additional countries in each IFCS region should have established a PRTR/emission inventory and countries without a PRTR/emission inventory should consider to initiate a national PRTR/emission inventory design process which involves affected and interested parties and takes into consideration national circumstances and needs.

This priority is part of a broader Forum PRTR/Emission Inventory Action Plan which is annexed to the Forum III Final Report.

9. Governments and industry should consider, subject to domestic regulatory requirements, or as provided for in international agreements, granting the public's right-to-know the chemical constituents of consumer products, at least on a qualitative basis, in order to enable them to make informed consumer choices.

Programme Area E:

Strengthening of national capabilities and capacities for management of chemicals

1. Countries should increase their efforts to systematically develop an integrated and coordinated approach to manage chemicals safely. Countries should therefore prepare and regularly update national profiles, identify capacity building priorities, and develop sound national action plans for them. Those countries that have completed a National Profile should make it as widely available as possible through such means as the UNITAR/ECB National Profile Internet Homepage.

By 2002, National Profiles, based on a multi-stakeholder process, should have been developed by most countries.

By 2002, all countries should have designated an appropriate contact point (IFCS National Focal Point) and have established an intersectoral coordinating effort.

2. National[37] policies or action plans should be developed through a multi-stakeholder process and based on information from the National Profiles. These policies/plans should be reviewed and revised from time to time as required. This should include information and details pertaining to all of the following:

- the development of effective national legislation, policies and enforcement,
- implementation of educational programmes and other projects designed to raise national awareness,
- capacity building related to risk reduction/risk management,
- strengthening institutional mechanisms and programmes,
- strengthening national information systems, networks, and Internet links.

Safer and cleaner technologies must be utilised to avoid, or to greatly reduce, risks from hazardous chemicals to the health and safety of workers, the general population, and to the environment. The development and use of these technologies should be in National Action Plans. Industry has a special obligation to participate in the implementation of risk reduction programmes.

Although risk reduction activities are primarily national responsibilities, regional and international risk reduction programmes are warranted for those problems that are sub-regional, regional and international in scope.

By 2005, national policies with objectives, priorities, strategies and action plans with targets for improving the management of chemicals should have been developed in most countries and regions.

3. Countries requiring external assistance should include capacity building for the management of chemicals as a national priority for development assistance and coordinate among relevant ministries clear and well-defined requests for external additional resources. In programmes against poverty, for agricultural development etc, the dimension of environment should be included, and other ministries such as those of planning should be involved. The Forum urges donor countries and organizations to undertake to strengthen their assistance programmes, at both policy and technical levels, and to report progress through the OECD biennial reports on assistance.

37. Whenever in this text the term national is used, it means national or other institutional level as appropriate.

OECD countries, other IFCS participants, non-profit organizations, and other institutions, should begin to work immediately to mobilize sufficient financial resources and technical assistance for the sound management of chemicals, including technology transfer as appropriate, providing opportunities to all countries to support activities under all the Forum programmes of action.

The Forum Standing Committee should review assistance given to countries to support capacity building for the sound management of chemicals and report back to Forum IV.

The Forum encourages coordination at international level of the various efforts to support strengthening of capacities in developing countries and countries with economies in transition, integrating work on Prior Informed Consent (PIC), persistent organic pollutants (POPs), obsolete stocks, Pollutant Release and Transfer Registers (PRTRs), pesticides etc. to the extent possible and based on the specific and explicit demands of countries seeking support for strengthening their chemicals management.

4. Enhanced access to information on various aspects of capacity building activities and needs related to the sound management of chemicals is a prerequisite for planning, implementing, evaluating and coordinating capacity building projects for the sound management of chemicals. As such it may also contribute to international, regional and national efforts to raise the awareness about the need for increased assistance to strengthen national capacities and capabilities for the sound management of chemicals.

The Forum supports the development of an Information Exchange Network on Capacity Building for the Sound Management of Chemicals within the framework of the IFCS and calls upon countries, international organizations, industry, labour unions, public interest groups and the academia to actively participate in this effort by 2003.

Programme Area F:

Prevention of illegal international traffic in toxic and dangerous products

1. The Forum requests that the Inter-Organization Programme for the Sound Management of Chemicals (IOMC) participating organizations establish a working group on illegal trafficking, drawing on the expertise of the Forum and considering recommendations given by the regional groups. This working group shall build upon ongoing activities within the IOMC participating organizations and shall assess illegal traffic in toxic and dangerous substances, review measures to detect and prevent illegal traffic, and make recommendations as to how its participating organizations may advance, add value to, and help integrate the work undertaken by other organizations, such as Interpol, the Organization for Prohibition of Chemical Weapons, and the World Customs Organization. This assessment and recommendations shall be considered by Forum IV; interim reports on the progress of analysis should be made to the Forum Standing Committee in the following areas:

- **national legislation and enforcement programmes;**
- **capacity to detect illegal import and export;**
- **resources and operational mechanisms for technical assistance for developing countries and for countries with economies in transition;**

- **the extent of illegal traffic at international, regional, sub-regional, and national levels, and the assessment of its impact at these levels;**
- **the extent of coordination and cooperation among all stakeholders;**
- **how international conventions related to the sound management of chemicals and national laws may be more effectively applied to the transboundary movement of chemicals.**

2. The Forum recommends that governments elaborate national strategies of prevention, detection, and control of illegal traffic, including the strengthening of laws, judicial mechanisms, and the capacity of customs administrations and other national authorities to control and prevent illegal shipments of chemicals, by enhancing information systems, e.g. case reporting systems, training, and other practical measures. In particular, in line with Article 13 (1) of the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, countries should give appropriate support to initiatives taken by World Customs Organization members aiming at the attribution of specific harmonized system codes for certain chemicals falling under the Rotterdam Convention and POPs, and enabling their comparison to environmental compliance data.

LIST OF ACRONYMS

ARET	Canadian Accelerated Reduction/Elimination of Toxics Programme
CARAT	Chemical and Risk Assessment Thesaurus
CBA	Cost Benefit Analysis
CEFIC	European Chemical Industry Council
CEH	Chemical Economics Handbook
CFCs	Chlorofluorocarbons
CIA	U.K. Chemical Industries Association
CMA	U.S. Chemical Manufacturers Association (now called the American Chemistry Council)
CO_2	Carbon dioxide
C&E News	Chemical Engineering News
DDT	Dichlordiphenyl trichloroethane
EEA	European Environment Agency
EPA	U.S. Environmental Protection Agency
EPR	Extended Producer Responsibility
ERNS	Emergency Response Notification System
EU	European Union
FAO	Food and Agriculture Organisation (United Nations)
GHG	Greenhouse gas
GHS	Globally Harmonised System (for classification and labelling)
HBFCs	Hydrobromofluorocarbons
HCFCs	Hydrochlorofluorocarbons
HPV	High Production Volume
ICCA	International Council of Chemical Associations
IEA	International Energy Agency
IFCS	Intergovernmental Forum on Chemical Safety
ILO	International Labour Organization (United Nations)
IOMC	Inter-Organisation programme for the sound Management of Chemicals
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IPP	Integrated Product Policy
ISO	International Organization for Standardization
MAD	Mutual Acceptance of Data
MARS	Major Accident Reporting System
MITI	Japan's Ministry of International Trade and Industry
MPD	Minimum Pre-marketing set of Data
NGO	Non-Governmental Organisation
NO_x	Nitrogen oxides
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substances
OECD	Organisation for Economic Co-operation and Development
PBB	Polybrominated biphenyl
PBT	Persistent, Bio-accumulative and Toxic

PCB	Polychlorinated biphenyl
PIC	Prior Informed Consent
POPs	Persistent Organic Pollutants
PRTRs	Pollutant Release and Transfer Registers
RSEI	US EPA's Risk Screening Environmental Indicators Model
PVC	Polyvinyl chloride
SEA	Socio Economic Analysis
SIDS	Screening Information Data Set
SMEs	Small and Medium sized Enterprises
SOCMA	Synthetic Organic Chemical Manufacturers Association
SO_x	Sulphur oxides
TRI	Toxics Release Inventory
UNCED	1992 United Nations Conference on Environment and Development
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNITAR	United Nations Institute for Training and Research
VOCs	Volatile Organic Compounds
WHO	World Health Organisation (United Nations)

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OECD Environmental Outlook for the Chemicals Industry

The global chemicals industry is an important part of the world economy. With an estimated US $1500 billion in sales in 1998, it accounts for 7% of global income and 9% of global trade, and it employs over 10 million people worldwide. Chemicals produced by the chemicals industry are present in countless products used by consumers, from pesticides and automobiles to toys and clothing. However, the possible risks from exposure to chemicals throughout all stages of their lifecycle and the environmental sustainability of chemicals production and use deserve careful attention. While the chemicals industry has made progress in reducing its overall environmental footprint, chemicals can still have a negative impact on human health and the environment.

The *OECD Environmental Outlook for the Chemicals Industry* begins with an outlook to 2020 for the production, use and consumption of chemicals in OECD countries and other parts of the world. The Report then gives an outlook to 2020 for the environmental impact from the chemicals industry and reviews the wide range of past and current policies designed to manage risks posed by the production and use of chemicals. It concludes with an identification of key chemical safety issues for the future, and a discussion of policy options to address these issues.

The *OECD Environmental Outlook for the Chemicals Industry* has been prepared to support the chapter on the chemicals industry of the *OECD Environmental Outlook.*

More information on OECD's work related to chemical safety is available at **http://www.oecd.org/ehs**; information concerning OECD's work related to the environment is available at **http://www.oecd.org/env.**

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