COMMITTEE ON
THE CHALLENGES OF
MODERN SOCIETY

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NATO/CCMS Pilot Study

Clean Products and Processes
(Phase I)

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1999 Annual Report
NATO/CCMS Pilot Study

Clean Products and Processes
(Phase I)

Report Number 238

U.S. Environmental Protection Agency
Queen's University
Belfast, Northern Ireland, United Kingdom

NOTICE

This report was prepared under the auspices of the North Atlantic Treaty Organization's Committee on the Challenges of Modern Society (NATO/CCMS) as a service to the technical community by the United States Environmental Protection Agency (U.S. EPA). The document was funded by U.S. EPA's National Risk Management Research Laboratory under the direction of E. Timothy Oppelt. The Annual Report was edited by Jean Dye and produced by Carol Legg of U.S EPA's Technology Transfer and Support Division. Mention of trade names or specific applications does not imply endorsement or acceptance by U.S EPA.

Contents

Introduction

The Committee on the Challenges to Modern Society (CCMS) was established by the Council of the North Atlantic Treaty Organization (NATO) in 1969. The mission of CCMS is to develop meaningful programs to share information among countries on important environmental and societal issues that complement other international efforts and to provide leadership in solving specific problems facing modern society. A fundamental role for CCMS is the transfer of technological and scientific solutions among nations facing similar environmental challenges.

The goal of reaching sustainable development, where human activities, including industrial manufacturing and commercial services, exist in harmony with the natural environment, including conservation of resources and energy, is an increasingly important aspiration for the nations of the world. With increasing populations demanding improved standards of living comes increasing industrialization and production. Also, with an expanding global marketplace and the explosion of information technology, social pressures on industries to become "greener" are increasing. The challenge to nations and industries is the achievement of sustainability while successfully competing in a global marketplace. We established this CCMS pilot study on Clean Products and Processes to create an international forum for open discussion on applying cleaner industrial processes and producing cleaner products around the globe. By discussing, debating, and sharing current trends, developments, and expertise in the use of cleaner technologies and production of cleaner products, we hope that this pilot study will stimulate productive interactions among international experts, with the end result being effective technology transfer.

The second meeting of the pilot study was held in Belfast, Northern Ireland, on March 21-25, 1999. This meeting capitalized on the momentum of the first year of the pilot study, focusing on progress made on several pilot projects being implemented by participating nations and building a program of collaborative endeavors, including information exchange and industrial participation in the pilot study. There were several guest lectures on significant developments in government programs, academic research and industrial applications. This report presents the ideas and views shared by the delegates and invited participants at the Belfast meeting.

As we move ahead into the second year of this pilot study, we want to thank Professor Jim Swindall, Director, Queen's University Environmental Science and Technology Research Center, Queen's University, Belfast, for his gracious hospitality and tireless efforts in planning and hosting the second meeting of the pilot study. We now look forward to continuing to build strong, cooperative relationships with our fellow delegates as we plan the third meeting of the pilot study to be hosted by Mr. Henrik Wenzel, Technical University of Denmark, and held in Copenhagen, Denmark, in May 2000.

Subhas K. Sikdar, Pilot Study Director
Daniel J. Murray, Jr., Pilot Study Co-Director

Welcome and Opening Comments

Dr. Subhas Sikdar, Director of the NATO CCMS Pilot Study on Clean Processes and Products, extended a warm welcome to all attendees of the pilot study's second annual meeting on March 21, 1999, in Belfast. He emphasized that the main objective of the pilot study is for nations to work together to avoid environmental pollution through information exchange. This meeting provides an ideal forum for sharing knowledge and stimulating dialogue amongst the international participants.

At the first meeting in Cincinnati in 1998, an agenda was created for the pilot program and eight research projects were selected for investigation. Dr. Sikdar explained that during this current session, delegates would be updated on the status of these projects while getting an opportunity to propose additional projects for inclusion in the program. In addition, invited guests would give a range of presentations on various tools for encouraging clean processes in industry.

Dr. Sikdar closed by outlining the expected outcome of the conference. This included fostering communal understanding of the concepts of clean products and processes, seeking collaborative efforts on research products, and enhancing the groups' understanding of state-of-the-art techniques in pollution prevention through technology transfer.

Professor Adrian Long, Dean of Engineering at Queen's university in Belfast, then welcomed everyone on behalf of the staff of the Queen's University Environmental Science and Technology Research Centre. He acknowledged the tremendous developments that have taken place at the Centre in the last ten years and stressed the excellent work which has been accomplished in providing answers to environmental problems through industrial and academic collaborative efforts. Overall, the Centre has brought in £11 million in research funding to the University and was awarded the Queen's Anniversary Prize in 1997.

Professor Long closed by encouraging attendees to enjoy the sights of Northern Ireland, particularly the majestic scenery of the Antrim coast, and to sample the delights of the famous Bushmills Distillery.

Goals and Objectives of the NATO/CCMS Pilot Study on Clean Products and Processes
(Daniel J. Murray, Jr., U.S. Environmental Protection Agency)

Mr. Daniel Murray Jr. of the United States Environmental Protection Agency began his presentation by emphasizing that the fundamental purpose of NATO's Committee on the Challenges to Modern Society is the exchange oftechnological and scientific solutions among nations with similar environmental challenges. As they move toward a true global economy and as the demands for sustainable development grow, all nations are faced with the challenges of creating cleaner and economically sound manufacturing sectors. The Pilot Study on Clean Products and Processes was established to create an international forum where current trends, developments, and expertise in the application of cleaner manufacturing processes and the creation of cleaner products could be discussed, debated, and shared to prevent and reduce environmental pollution and move toward sustainability.

Therefore, the goals ofthe pilot study are to create opportunities for technical information exchange and cultivation ofprofessional relationships among national representatives. To do this the pilot study will:

- hold annual meetings to facilitate scientific and technological interaction among participating countries;
- identify common issues and challenges to effectively focus the pilot study on global problems;
- encourage the participation of all nations to collectively face current challenges and share advances in science and technology; and
- focus on the technical and scientific aspects ofclean production and the application oftools and methodologies rather than onnational and international policies.

The first annual meeting ofthe pilot study was held in Cincinnati, Ohio in March, 1998. A total of fourteen nations were represented and these agreed that the core focus ofthe pilot study would be pollution associated with processes and products. In addition, the meeting attendees decided that the pilot study would have a continual focus on tools and methods to assess, prevent, and solve pollution problems; onindustry- and sector-specific problems; and on product- and service-specific issues. These include life cycle analysis tools, cost-benefit assessment tools, and communication and information tools.

At this meeting five priority industrial/service sectors were identified including textiles, organic chemicals, energy production, pulp and paper, and food production. The first Annual Report (NATO #230) was published in June, 1998 and the electronic version (.pdf) is available on theNATO/CCMS web site.

Also, at that meeting the first round ofpilot projects was selected. They include:

- Product Oriented EnvironmentalMeasures in the Textile Industry - Denmark
- PollutionPrevention Tools-United States
- Energy Efficiency - Moldova
- Water Conservation and Recycling in the Semiconductor Industry -United Kingdom and United States
- Research and Development Aimed at Developing Cleaner Production Technologies to Assist the Textile Industry - Turkey

- Cleaner Production through the Use of Intelligent Systems in the Pulp and Paper Industry - Canada
- Pollution Prevention Development and Utilization - United States
- Cleaner Energy Production with Combined Systems - Turkey

Tasks for the second annual meeting include the reaffirmation ofthe goals and objectives for pilot study, reevaluating the prioritized listing of industrial/service sectors, identifying new pilot projects, expanding the participation ofnations, initiating the preparation ofthe second annual report, and planning the third annual meeting in 2000. In reaffirming or revising these goals and objectives, the delegateswill set the course for the next three years ofthe pilot study.

Guest Presentations

Process Integration Technology for Clean Processes
(Russell F. Dunn, SOL UTIA, Florida, U.S. A.)

Dr. Russell Dunn works in the area ofprocess integration technology for Solutia Inc., in Pensacola, Florida, which is the largest manufacturing site for Nylon 66 in the world.

Significant progress in the development of design tools for clean processes has been made over the past decade. These advances have been in response to increasingly stringent environmental regulations and sustained pressure on industry to identify cost-effective pollution prevention strategies. The design tools developed are collectively groupedunder the heading of "process integration technology."

Process integration technology was defined by Dr. Dunn as the optimal allocation ofmassand energy within a unit operation, process or site (see Figure 1). There are two key elements within any industrial process/plant: a

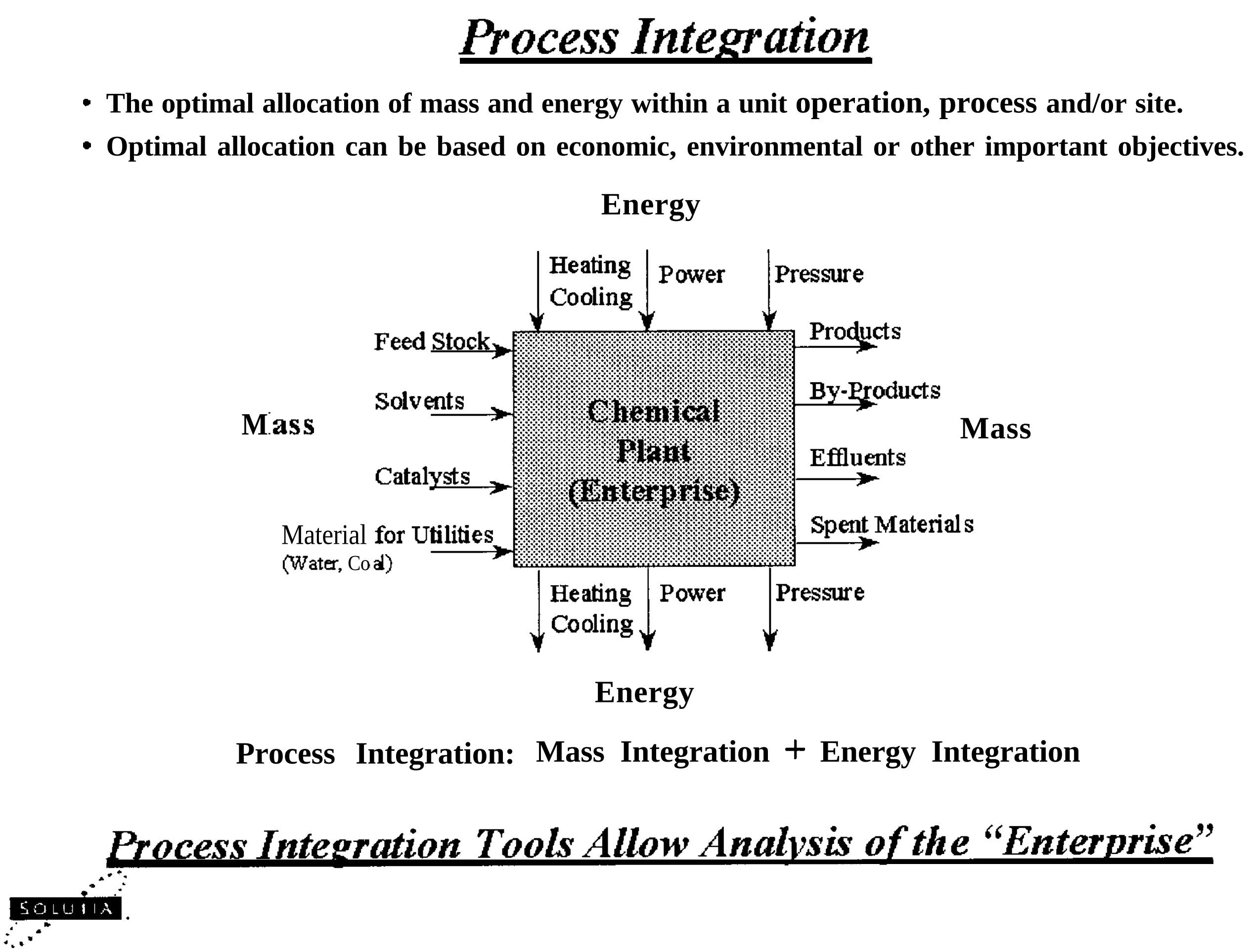


Figure 1. Process integration technology.

mass dimension which involves the raw materials products and effluents and an energy dimension which involves the energy necessary to drive the process, The two are interrelated and the objective is to optimally allocate mass and energy within the industrial process/plant. Usually this is driven by economic and environmental objectives.

When designing a single chemical reactor, an engineer may use molecular modeling initially and kinetics and diffusion as the scale gets larger. Ultimately, the reactor vessel required is designed using computational fluid dynamics to look at hydraulics, kinetics, and mass transfer. Eventually, the designer will evaluate how the vessel fits into the overall plant. This is where process integration is applicable.

Process integration tools can be classified into three categories. The first category consists ofa series of management tools that target the conservation and reuse of streams containing pollutants that are not a part ofthe manufacturing process. The second category consists ofsystems analysis tools which allow the designer to analyze a large system and determine the optimal strategy to address a given environmental task. The third category of design techniques for pollution prevention focuses on developing robust, cost-effective solutions using interception technologies (unit operations). A holistic approach for using these tools for water conservation and reuse design has been developed and is referred to as the Water Allocation Design and Engineering (WADE) methodology.

Dr. Dunn briefly discussed three water management tools including process instrumentation, environmental audits, and environmentally focused walk-throughs. At an industrial level there are two types ofwater: waterused in the process which shows up on a process flow diagram as part ofthe manufacturing process and non-process water used forwashing down equipment. These streams are managed through process instrumentation which means using gauges to get data on water streams, flowrates etc. The idea behind the environmental audits and walk-throughs is for management to take an active role in looking for non-process water usage. This is not very technical but it is vital to address non-process water streams to reduce wastewater.

Dr. Dunn then talked about using systems analysis tools to breakdown a problem. The first design tool he addressed was “source-sink stream representation” (see Figure 2). To elaborate on this, Dr. Dunn utilized wastewater minimization as an example process while specifying that it is not necessary to use these tools for wastewater streams; in fact they can be used to solve any environmental problem. Source streams represent wastewater outlet streams in this example, or terminal streams at the end of a process. These streams are broken down into individual streams so it is possible to visualize what waste streams exist in the plant. Likewise it is possible to look at the individual streams which are required in different unit operations within the process called sink streams. Within unit operations there is an acceptable range offlowrate and composition for each sink stream. The question becomes, how can designers systematically identify opportunities for using source streams within sinks.

By developing othertools it is possible to arrive at the answers quickly. Interceptiontechnologies can be used to clean up streams for a particular unit operation ifthe composition or flowrate are not acceptable. These recycling opportunities are identified by means of a second key tool, the “source-sinkmapping diagram” (seeFigure 3). Here, water load/flowrate is plotted against the composition of a particular pollutant. In a typical manufacturing process, there are several wastewater streams at different flowrateswith different constituents, but there are also a series of sinks which require these constituents for certain unit processes. This information can be plotted on a single representation to identify direct recycling opportunities where composition similarity exists. This also helps determine what streams can be mixed to get the right composition for reuse and, if necessary, an interceptor technology can be introduced to reduce the composition of a constituent to the required level. This is a simple but effective tool and is valuable because it identifies what level of cleanliness is necessary thus eliminating the potential for overdesigning treatment systems.

Source-Sink Stream Representation Diagram

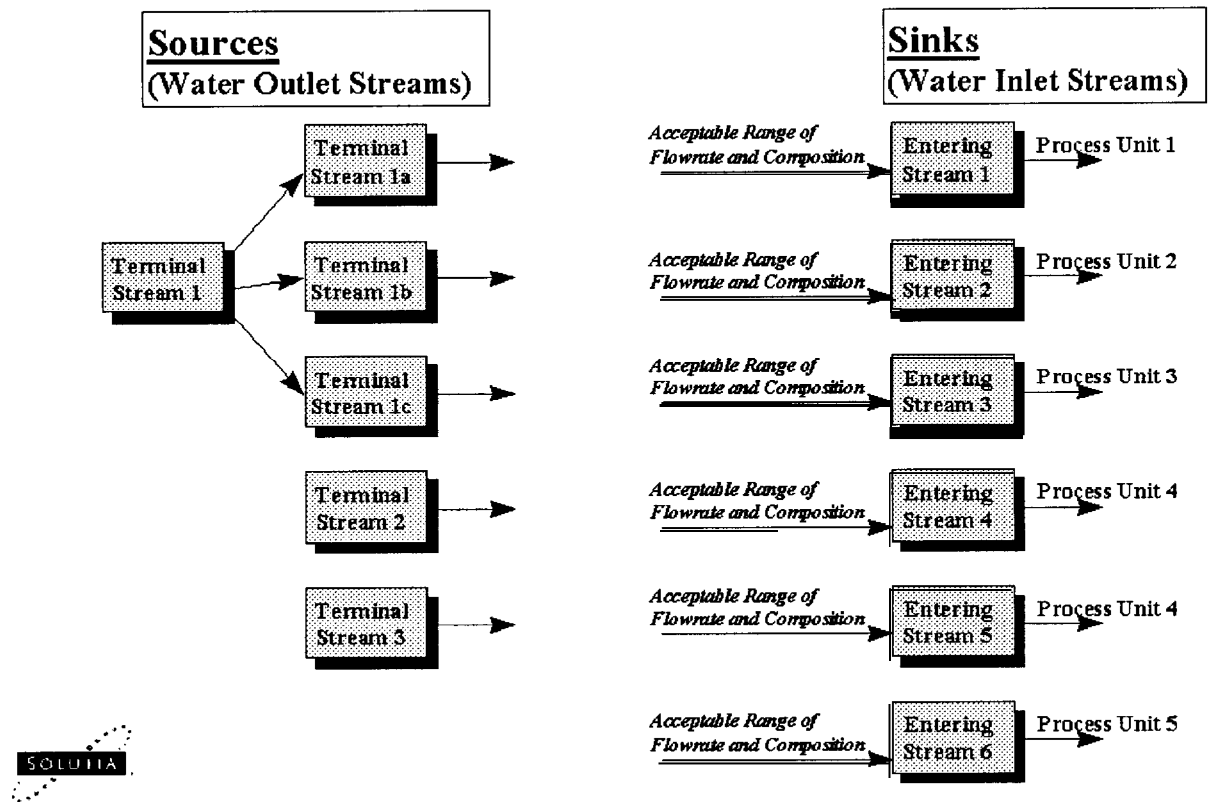


Figure 2. Source-sink stream representation.

This tool can handle multi-component streams but generally a diagram is introduced for all of the key species of interest. In reality, for any particular design for direct recycle there will be a limiting constituent and it is possible to identify from the graph which of the components within the streams happen to be the most stringent or most limiting. Mathematical algorithms can be used to solve this problem, but the use ofindividual graphs is a simpler method of coming up with options to solve these problems. It is systematic and very rapid.

Another important tool is the "path diagram." For any process flow diagram that involves several unit operations with several streams, a path diagram can be used to illustrate all of this in a single representation. Figure 4 illustrates a path diagram where the dots represent a stream and the lines represent a unit. This graphical representation is important because it gives a clear benchmark of any interception changes or changesinmass flow or compositions in the heart oftheprocess and outlines how these affect subsequent units. Adifferent path diagram is prepared for each key species. This gives tremendous insight into the overall process.

Dr. Dunn then discussed interception technology tools in two key areas, end-of-the-pipe design tools versus in-plant interception design tools, Over the past ten years there has been significant work done to develop these techniques to address some element of pollution prevention (see Figure 5). What is critical is knowing which technique to use to solve a particular problem.

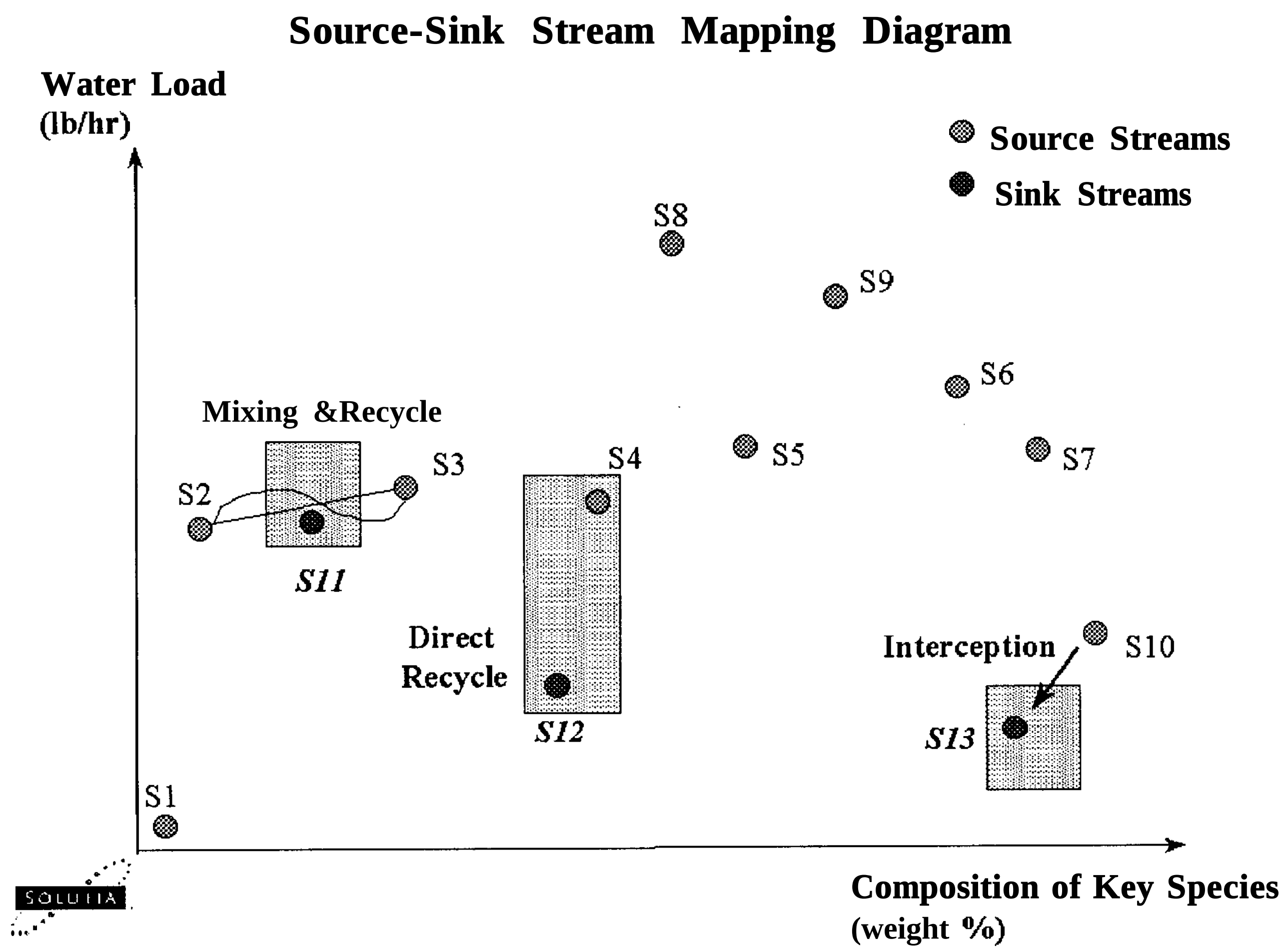


Figure 3. Source-sink stream mapping representation.

When interceptor technologies are used there are multiple options that can be employed for cleaning up streams. A major breakthrough in this particular area was the introduction ofa mass exchanger which is defined as any direct-contact, counter-current mass transfer unit (see Figure 6). There are several examples ofthese types of unit operations. The real breakthrough was introduced in 1989 by El-Halwagi and Manousiouthakis and it involves looking at the overall plant, no matter how many unit operations there are, and designing a grouping of mass exchange networks, whichis a system of one or more mass exchangers, to look at all ofthesetypes ofprocesses simultaneously. Because ofthe similarity ofthese processes, given they are all direct-contact, counter-current units, it is possible to analyse them simultaneously. This is a complex procedure based on the concept of mass pinch technology, but it has been done successfully and there are numerous articles illustrating the approach.

Dr. Dunn extended this idea to the concept ofa heat induced separator which does not involve contactor streams but rather involves the use of an energy separating agent as opposed to a mass separating agent. Here, energy is used to separate out streams via a phase change. Dr. Dunn introduced the concept ofdesigning a network ofheat induced separators (e.g., condensors, evaporators) which involves one or more ofthese operations to separate gaseous or aqueous emissions streams at the end ofthe pipe via phase change, to achieve environmentally acceptable emissions streams. These streams are valuable becausethey can be recycled. Extending this further, an

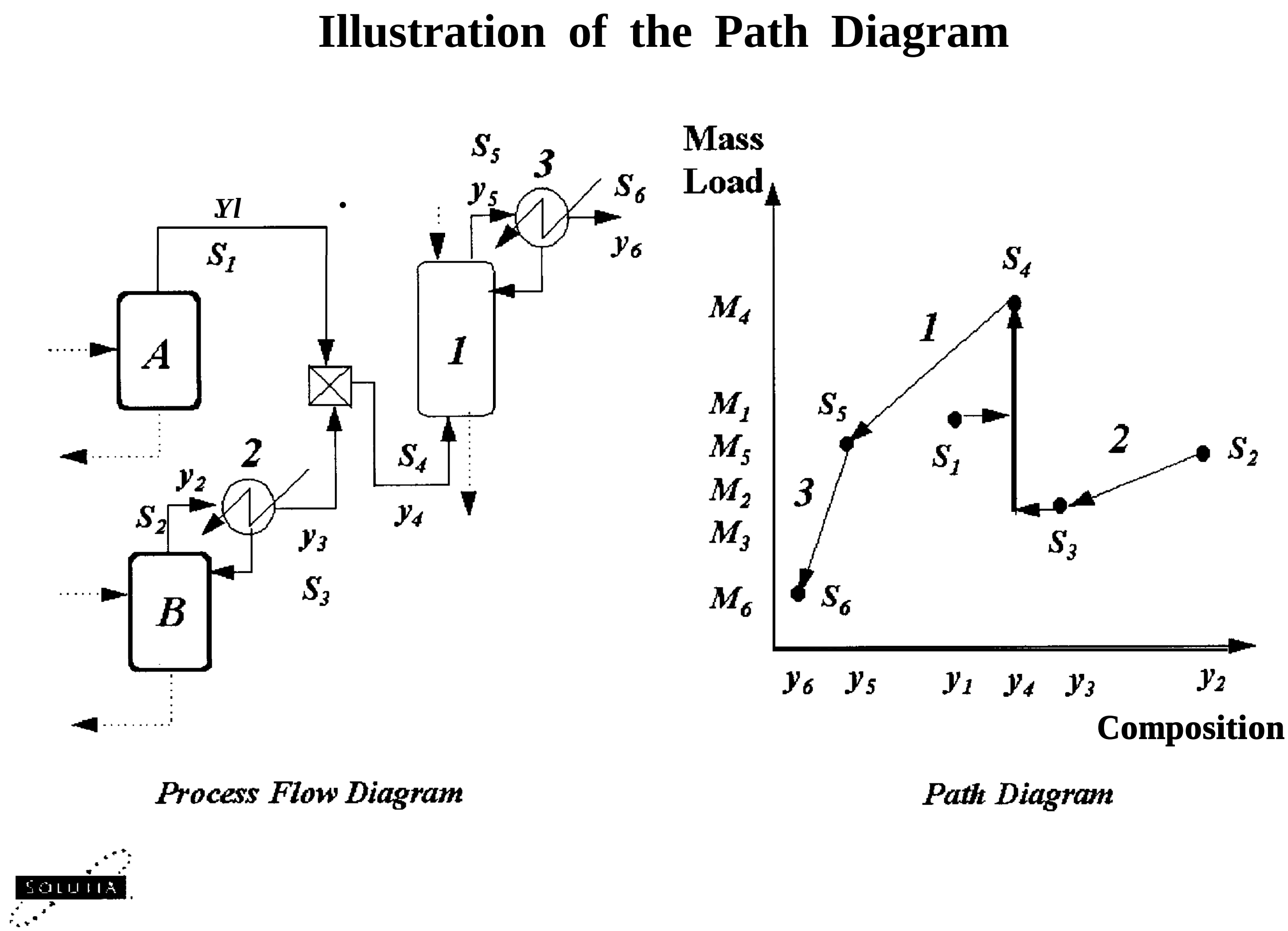


Figure 4. Path diagram.

energy induced separation network not only incorporates these heat-transfer type unit operations, but also involves the use ofpressurization and depressurization techniques to enhance the thermodynamics ofthe separation.

The final technique discussed by Dr. Dunn was the waste interception and allocation networkwhichis based on the concept that it is cheaper to perform separations in the heart ofa process. When pollutants areformed early it is more prudent to perform a separation within the heart ofthe plant, so by the time the streams reach the end of the pipe they are already environmentally acceptable. Along the same lines, using energy separators and/or pressurization techniques within the heart ofthe plant can also yield the same kind ofeffects and there are numerous case studies to illustrate the cost-effectiveness ofthese technologies.

In conclusion, there are a series of existing process integration tools that are effective, even though it may take some timeto learn how to use them correctly. Using these analyses techniques at the SolutiaPensacola site resulted in a reduction of 650 gallons/min ofwastewater which was approximately 3 5% ofthe entire wastewater flow. Dr. Dunn outlined similar success stories at other sites. Ultimately, these tools allow engineers to address problems at large sites in a very short period of time.

Process Integration for Pollution Prevention: Interception Technologies Design Tools Developed to Date

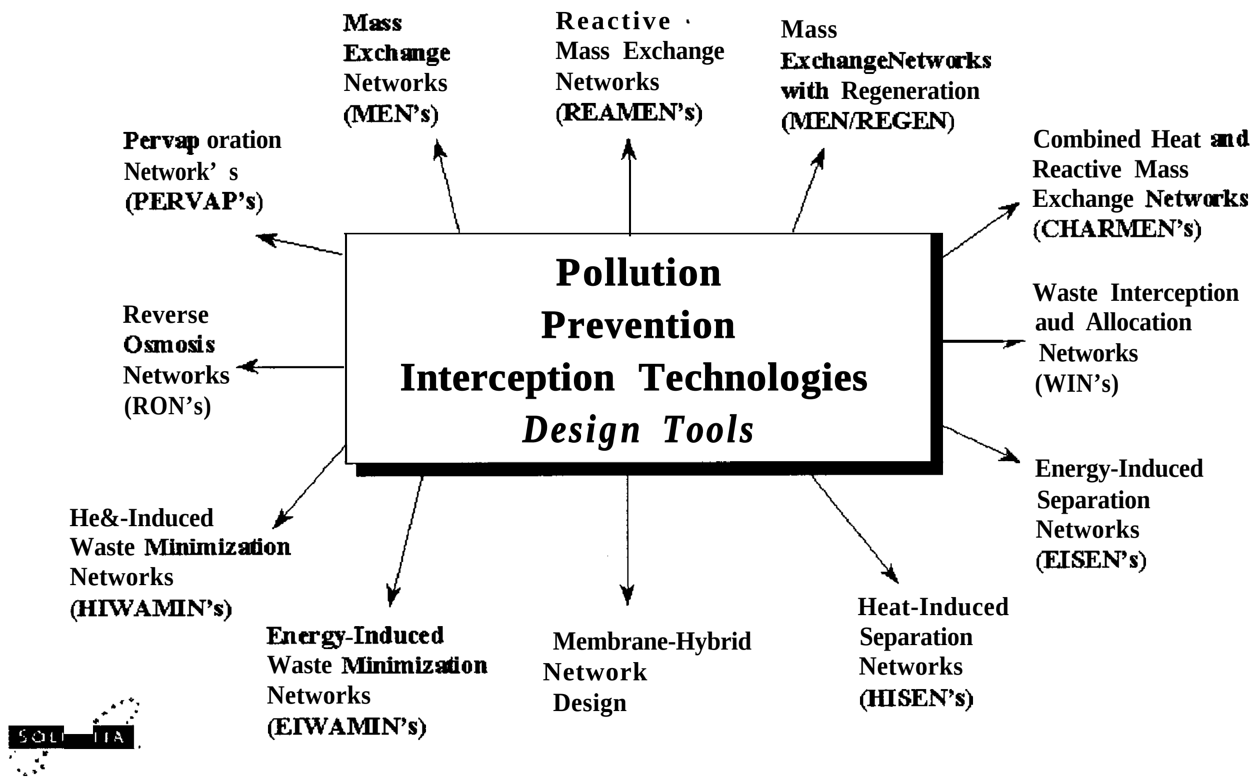
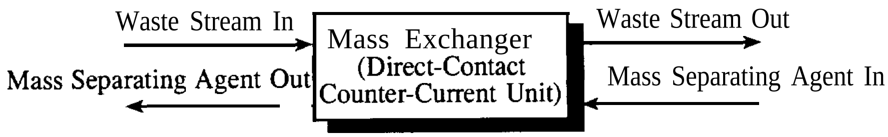


Figure 5. End-of-the-pipe design tools and in-plant intercept& design tools.

End-of-the-Pipe Design Tools

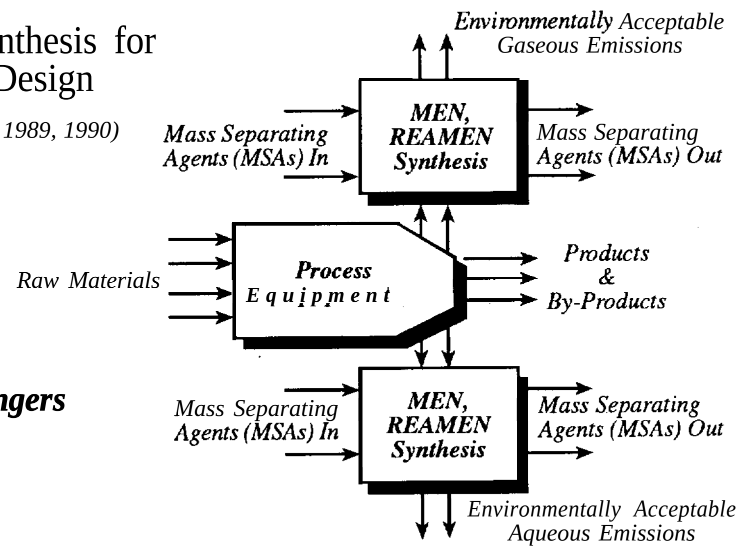
Schematic of a Single Mass-Exchanger for Environmental Process Design



Examples of Mass-Exchangers are Absorbers, Adsorbers, Ion-Exchange Units, Liquid-Liquid Extraction Units, etc.

Mass-Exchange Network Synthesis for Environmental Process Design

(El-Halwagi and Manousiouthakis., 1989, 1990)
(El-Halwagi and Srinivas, 1992)
(Srinivas and El-Halwagi, 1994a)
(Dunn and El-Halwagi, 19%)



A Mass Exchange Network is a System of One or More Mass Exchangers

SOLUTIA

Figure 6. Mass exchanger for environmental process design.

Ionic Liquids: Neoteric Solvents Research and Industrial Applications
***(Kenneth R. Seddon, School of Chemistry, The Queen's University, Belfast)* ***

Clean technology involves reducing waste from anindustrial chemical process; it requires rethinking and redesigning many current chemical processes. The&factor of a process is the ratio, by weight, ofthe by-products to the desired product(s)[1]. Table 1 illustrates that the 'dirty' end ofthe chemical industry, oil refining and bulk chemicals, is waste conscious; fine chemicals and pharmaceutical companies use inefficient, dirty processes, although on a much smaller scale. Volatile organic solvents are the normal media for the industrial synthesis of organics (petrochemical and pharmaceutical), with a current world-wide use of about £4,000,000,000 yearly. However, the Montreal Protocol produced a need to re-evaluate many chemical processes that have proved satisfactory for much ofthis century. There are four main alternate strategies: (1) solvent-free synthesis, (2) the use ofwater as a solvent, (3) theuse ofsupercritical fluids as solvents, and (4) the use ofionic liquids as solvents. It is the purpose of our work to explore option 4.

Table 1. Chemical Industry E-factor Comparison

Industry	Production I tons yearly	E-factor
Oil Refining	10^6 - 10^8	0.1
Bulk Chemicals	10^4 - 10^6	1-5
Fine Chemicals	10^2 - 10^4	5-50
Pharmaceuticals	10' - 10^3	25-100

Our progamme explores, develops and aims to understand the role ofionicliquids as media for industrially relevant synthetic organic chemistry. Ionic liquids have, among other things, the following desirable properties: (1) they have a liquid range of 300°C, allowing kinetic control, (2) they are outstanding solvents for a wide range of inorganic, organic and polymeric materials: high solubility implies small reactor volumes, (3) they exhibit Bronsted, Lewis, and Franklin acidity and superacidity[2], (4) they have no effective vapour pressure, (5) their water sensitivity does not restrict their industrial applications, (6) they are thermally stableup to 200°C, and (7) they are cheap and easy to prepare[3]. Unlike water and other hydroxylic solvents, they will dissolve a wide range of organic molecules. Work in our laboratories, carried out in collaboration with BP and Unilever, showed that many catalysed organic reactions, including oligomerizations, polymerizations, alkylations, and acylations, occur in room-temperature ionic liquids, and are serious candidates for commercial processes. The reactions we have seen are the tip of an iceberg; all signs are that room-temperature ionic liquids are the basis of a new industrial technology. They are designer solvents, and some ofthe design principles were outlined in the lecture.

Examples of industrial relevance discussed include:

(a) Synthesis ofpoly(isobutene)[4]

(b) Friedel-Crafts chemisty

* Additional information on ionic liquids research at Queen's University is available on the Internet at *http://www.* ch. *qub. ac. uk/ krs/krs.html*

(c) *N*- and *O*- alkylations

(d) Diels-Alder chemistry

Acknowledgements

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U.S. Industrial Energy Efficiency Research, Including a Focus on Metal Casting
(Louis V. Divone, U.S. Department of Energy)

Mr. Divone began his presentation by emphasizing that competitive pressures on industry are huge. They encompass technology/product complexity, global markets and competition, the rapid pace of technological change, competing materials, customer pressure on costs, environmental regulations, stockholder demand for near-term profits, and the high cost and risk ofresearch and development. Also, energy efficiency gains have slowed. This is obvious when one reviews industrial energy intensity between 1974 and 1996 when it fell from 8,000 Btu/$ GDP in 1974 to 4,750 Btu/ $ GDP in 1986 and then levelled off at just above 5000 Btu/$ GDP in 1996. In addition, environmental compliance costs have climbed. Business pollution abatement and control costs have risen from approximately $10 billion in 1973 to over $80 billion in 1993.

In light ofthis, the collaborative U.S. Department ofEnergy/Industrial Energy Efficiency Research program was initiated to target energy- and material-intensive industries. Key developments in the program include the addition ofthe petroleum mining and agricultural sectors into the Industries ofthe Future program. The agricultural effort concentrates primarily on bioproducts; the replacement offossil hydrocarbons with renewable carbohydrates and other agricultural biomass materials, both selectively grown and agricultural waste. This brings the total sectors in the Industries ofthe Future program to nine; the others are aluminum, steel, metal casting, glass, chemicals, and forest products.

Selected targets for several industries were outlined. Recycling has to be increased to 25% in the forest products industry, with over 60% self-generation and closed water cycles. Steel targets include zero emissions with 70% of steel made from scrap. A productivity increase of 15% is targeted in metal casting; recycling is at 100% and energy use has decreased 20%. Energy use is down 50% in the glass industry; recycling is at 100% and emissions are down 20%. The aluminum industry has reduced energy use by 27%, reduced greenhouse emissions and increased lifecycle usage. There has been increased efficiency in the use ofraw materials and in reuse ofrecycled materials in the chemicals industry. In agriculture, renewable bioproducts will account for 10% ofthe industrial chemicals market by2020, and in the mining industry, safety and efficiency have increased.

Regarding program funding, there has been good support from the Administration with moderate support from Congress. Funding appropriation for fiscal year 1999 for specific industries ofthe future was $57.5 million and the requested appropriation for 2000 is $74 million. FY 1999 appropriation for crosscutting industries ofthe future was $100 million with a requested $87.6 million for FY 2000 (the decrease masks the fact that some programs have reached a successful conclusion and are naturally trailing off, thus requiring less funding, but the engineering technology base program is growing). Funding for management and planning which includes information and outreach was $8.4 million in 1999 and will be $9.4 million in 2000.

Key increased initiatives are being undertaken in aluminum, focusing on advanced new types of electrolytic cells, and advanced black liquor gasification technologies to succeed the Kraft boiler technology in the pulp and paper sector ofthe forest products industry.

Crosscut initiatives include the bioenergy initiative which covers forest products, agriculture, chemicals and gasification; energy-smart schools, combining heat, power and steam; the combined heat and power challenge with double installed capacity by 20 10; and special project grants for state level industries ofthe future.

Mr. Divone showed three charts illustrating expected energy savings, carbon reduction, and cost savings for specific and crosscutting industries of the future for the years between 2000 and 2020. Total cost savings are estimated to be $16.2 billion by 2020.

Industry program accomplishmentsinclude the addition ofvision industries such as mining and agriculture; highlighting technology such as Burns Harbor where Bethlehem Steel Corporation showcased 9 new technologies to invited guests and competitive steel companies, showing that the company was operating at a profit while being good citizens; and accelerated technology successes of $2.1 billion savings over the last 15 years.

Mr. Divone then provided a more in-depth description ofresearch collaborations with the metal casting industry. Metal casting has been carried out for several thousands ofyears. Every country in the world carries out metal casting to one degree or another. There are over 3 100 foundries in the U. S. and these are located in essentially every state, not including foundries inside ofother production facilities such as auto or aircraft plants. Metal casting is primarily a small-business industry with 80% ofU. S. foundries employing fewer than 100 persons each. Only 4% offoundries employ over 250 workers. Metal casting in the U. S. produced 14.1 million tons ofcastings valued at $22 billion.

The metal casting industry has developed a vision of its future involving aggressive energy and environmental long-term goals including achieving near 100% pre- and post-consumer recycling, 75% beneficial reuse offoundry by-products and elimination ofwaste streams. They are also aiming for increasing productivity by 15% and reducing lead times by 50%.

A research program was implemented which incorporates the annual solicitation ofprojects to address research objectives identified by industry in its vision and roadmap. The majority of research performers are universities. Proposal selection criteria are competitive and merit-based, and must support small business, be pre-competitive, and ofnational benefit (energy, environment, competitiveness and education). The role ofDOE is to act as facilitator, monitor progress and disseminate the results to industry.

Key new technologiesunder development to help achieve these goals include advancedlost foam casting, die life extension, sand reclamation, and intelligent control ofthe cupola furnace.

The advanced lost foam casting project was driven by researchers at the University of Alabama working with industry. The process involves making a pattern out of Styrofoam innumerous pieces which are glued together, thus facilitating complex casting in one step. This process uses 30% less energy, costs 25% less and has lower reject rates. Figure 1 illustrates the increased use of lost foam casting as a percent ofthe total aluminum casting.

Lost foam process improvements include: an air gauging system; vibration and compaction improvement; the use ofa distortion gauge, fill gauge, and compaction gauge; liquid absorption; and gas permeability. A successful lost foam showcase took place in October, 1998, in Birmingham, Alabama, with over 200 attendees from 12 countries. The technical sessions included: tooling for lost foam casting, foam pattern production and quality assurance, coatings for lost foam production, process controls, tolerancing and mechanical properties, and environmental benefits.

Another research project is investigating die life extension. The thermal fatigue resistance ofKDA- 1 steel has shown to be superior compared to premium grade H- 13 which is the typical steel used in dies. Testing has shown opportunities for increasing the die life by 50%. The results ofthis research are already producing cost savings in industry. The thermal fatigue resistance of steel improves at faster cooling rates. When a die is heat treated, using

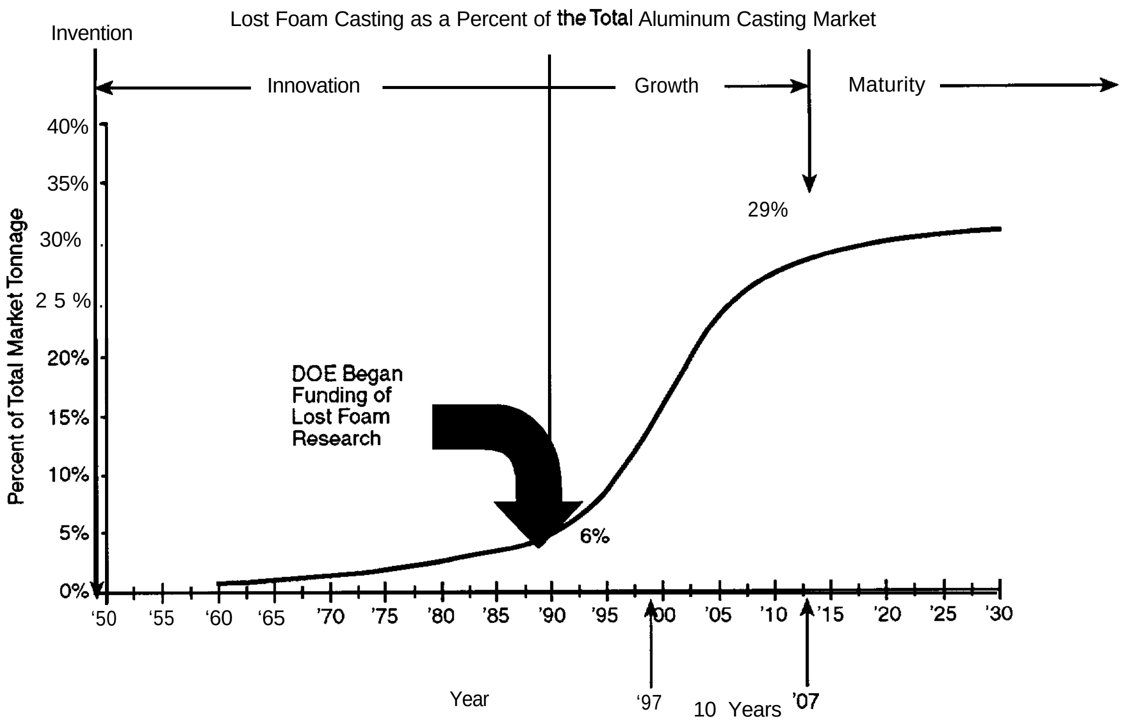

Figure 1. Increased use of lost foam casting as a percent of total aluminum casting.

conventional H- 13 steel, there is an increase in the number offatigue cycles; meanwhile KDA- 1 has shown itself far superior giving industry more options.

The final research project outlined by Mr. Divone was the intelligent control of the cupola furnace. An 18-inch experimental research cupola was designed and constructed to verify control algorithms. A trainable neural network was developed to provide steady-state relationships between selected cupola inputs and outputs. The feasibility of automatic control was demonstrated at the Albany Research Center. Potential benefits include: anticipated energy savings of 400 million BTUs per year per unit; applying modem techniques to improve the environmental performance of existing cupola technology; decreased coke requirements and elimination of associated emissions; reduced carbon, sulfur and manganese losses; and fewer rejects.

Additional information on the activities of the Office of Industrial Technologies is available on the OIT home page: www.oit.doe.gov

Clean Products and Processes from the Trade Union Perspective
(Mr. Peter Carter, MSF Union, London)

Mr. Carter began his presentation by expressing his pleasure at being present at the conference, and particularly to have an opportunity to present the viewpoint ofworkers affected by changes in technology.

The trade union (TU) movement in the United Kingdom generally supports environmental protection and supports production methods that are environmentally friendly. The TU statement in support of sustainable development is as follows: "The TU movement is involved in the debate around sustainable development and the promotion of sustainable employment; work places are a springboard to environmental quality and sustainable development must integrate economic concerns specifically regarding jobs creation." The International Federation on Free Trade Unions also supports the Kyoto protocol and agrees that there is a danger to jobs if climate change is not acted upon; therefore action is necessary.

Firstly, what is the role of a trade union? TUs exist to protect the interests oftheir members and they are concerned with issues such as pay, working conditions, health and safety, and job security. Also they are interested in the development of democratic structures which often don't make the hard choices necessary for environmental protection. While the TU movement takes a supporting view of environmental protection, in the work place there may seem to be conflict between environmental concerns and concerns for individual jobs. Public support for the environment can play a role within the workplace. A report to last year's Trade Union Conference outlined the limited progress made in environmental awareness since Rio de Janeiro. An important question is whether the TUs have failed to convince workers down the line that environmental protection is important and our personal concerns are affected by these concerns.

Mr. Carter then addressed how clean processes can change the way things are done at work. Approximately 3.5 million people were involved in environmental jobs in the European Union in 1997. Additional jobs will be created in the environmental sector. Changes in industry require different jobs, therefore different jobs will be created. The argument is that the overall impact onjobs will be small and will affect particular people. This is an important area to look at and it is important to have a social policy which addresses retraining. Throughout the unions in the UK there is support for skills development and training and continuing education. Also, consultation is vital. TUs are seen as opposing the development ofnew ways of doing things. They are more enlightened but the views oftheir members are important and there is a lot ofwork involved in supporting change.

Mr. Carter's TU has been involved in the debate about nuclear power and biotechnology. This TU has an ambivalent attitude to nuclear power but is supportive ofbiotechnology and has argued for more investment in research and development which leads to new ways of doing things.

TUs also wish to promote more environmentally friendly policies in the workplace, and a key way to achieve this is to involve TUs in discussing changeup front. This would help to ease the transition and reduce hostility to change from the work force. The TU wants its members to work for successful companies within competitive world markets.

To ensure support for cleaner ways of production, TUs should be invited to take part in environmental reviews in the work place, to be consulted, represented and to participate in committees. Then it becomes easier to see that change is necessary and TUs can therefore promote environmental policies.

The concern of the TU about the environment stems from the belief that environmental protection is important to its members, Environmental concerns are a major area of interest. Changes often take place due to market forces not environmental awareness. The TU movement supports a sustainable development approach and wants its members to work in organizations that are environmentally sustainable because these are theindustries that will survive.

Use of Supercritical Carbon Dioxide in Clean Production
(Paul Hamley, University of Nottingham, UK)

Dr. Paul Hamley began his presentation by asking what are supercritical fluids (SCFs)? SCFs are gases compressed until they are nearly as dense as a liquid. Like gases, SCFs are highly compressible and must be contained in closed vessels. Like liquids, SCFs can dissolve solid materials. They are currently arousing great interest as environmentally more acceptable replacements for conventional solvents in a whole range ofindustrial and chemical processes from dry cleaning to the production offine chemicals.

For nearly 200 years, scientists have been fascinated by watching liquids being heated in sealed tubes. When the liquid is heated, it expands and some of it evaporates. This makes the vapour above the liquid grow denser. Eventually, the vapour and liquid reach the same density and the meniscus between them becomes blurred and disappears. The liquid has become "supercritical."

Chemists describe this behaviour with a pH diagram, a plot ofpressure against temperature. The point where the boundary between gas liquid disappears is called the critical point. A fluid is "supercritical" when its temperature and pressure are above their critical values, T_c and P_c.

Heating a liquid in a transparent tube is difficult and potentially dangerous. Recently, in collaboration with Russian scientists, researchers at the Clean Technology Group at the University ofNottingham have developed an acoustic method. It works because the speed of sound drops to a minimum at the critical point. The apparatus is very simple, just a metal cross-piece, with a sound generator on one side and a microphone on the other. A measurement is taken ofhow long a pulse of sound takes to travel across the cell. The method works well and it is possible to find the critical points ofchemical mixtures, which are difficult to measure by other methods. The data are important for understanding chemical reactions in supercritical fluids.

Supercritical CO,, ($scCO_2$) is the most widely studied SCF. It is non-toxic and its T_c is close to room temperature. Many substances dissolve in $scCO_2$, and chemists are beginning to use it as a replacement for less environmentally acceptable solvents. Supercritical CO, is being exploited commercially to decaffeinate coffee and can also be used to control the precipitation of small particles, for example in the pharmaceuticals industry. Recently, researchers showed how precipitation of C60 (Buckminsterfullerene) leads to a finely divided yellow powder, even though larger crystals ofC60 are nearly black.

Chemical Reactions in Supercritical Fluids

SCFs offer chemists greater control over reaction chemistry. Reactions involving hydrogen (H_2) are particularly effective because H_2 is completely miscible with supercritical CO_2 ($scCO_2$). Toxic solvents can be avoided, equipment can be made smaller andunwanted side-products eliminated.

Most chemical reactions need a solvent, to aid mixing, to remove heat, and to control reactivity. Many solvents are toxic and their disposal poses problems. The Clean Technology Group is particularly interested in replacing organic solvents in chemical reactions. Their strategy is to demonstrate that SCF solvents give real chemical advantage as well as being environmentally more acceptable.

Hydrogen is only slightly soluble in conventional solvents, but it is miscible with $scCO_2$ because both substances are gases. The Clean Technology Group was the first to exploit this effect to makenew compounds. One example is a highly unusual manganese complex with H_2 bonded to the metal, which chemists had never expected to be isolated.

The addition of H_2 to an organic compound is called "hydrogenation." It is a fundamental industrial process. The Technology Group is collaborating with Thomas Swan & Co. Ltd and Degussa AGto develop supercritical methods to make hydrogenation safer and better. Their flow reactor is surprisingly smaller than a human hand, but it can still produce literally tons ofproduct per year.

The combination of $scCO_2$, solid catalyst and flow reactor is extremely efficient. In the hydrogenation of isophorone, 1 gram of catalyst can hydrogenate as much as 7.5 kilos ofisophorone before losing its activity.

Supercritical hydrogenation can be controlled with high precision because the $scCO_2$, the organic compound and the H_2 are all in a single phase. Of course, CO_2 is a greenhouse gas but theses reactions do not increase the problem. The CO, that weuse for all our work is the waste gas from other processes. So there is no increase in the amount of CO, produced.

Supercritical Fluids: Clean Routes to Polymers, Coatings and Bones

Polymers are important in a whole range ofindustries. Supercritical CO, can make production ofpolymers cleaner and oftengives greater control than conventional processing, leading to new and better products.

Several research groups, including Nottingham, are using supercritical CO, as a solvent for making polymers, The reactions are carried out in a high-pressure vessel, about the size of a coffee mug. Unlike conventional processes, the polymer comes out ofthe reaction "clean" and dry. The only residue is CO, which quickly diffuses away.

The swelling ofpolymers by CO, has been used commercially by Ferro Corporation (USA) to produce powder coatings -paints for use on cars, fridge/freezers, etc. The coatings consist ofparticles of coloured pigment coated in polymer, like tiny sugar-coated sweets. Supercritical swelling makes the mixing ofthe pigment and the polymer much more efficient, and allows the process to be carried out at lower temperatures, leading to a much wider range ofpossible paints.

The Clean Technology Group has led a three-way collaboration among Nottingham, Ferro and a group in Moscow, to adapt this technology to make synthetic bone materials. Calcium hydroxyapatite (the inorganic constituent ofbones) is mixed with biodegradable polymers. By careful control, the resulting composite has avery high loading ofcalcium hydroxyapatite and it is also full ofholes which are almost exactly the same asin real bone. This porous structure means that the new material is ideal for surgeons who need to repair patients' bones. An added attraction is that the process is clean; only CO, isused.

The Clean Technology Group gratefully acknowledges support from the Royal Society, the Royal Academy ofEngineering, EPSRC, EU, NATO, the Gatsby Foundation, the Paul Instrument Fund, Thomas Swan & Co. Ltd, Degussa AG, ICI, SmithKline Beecham, Ferro Corp., DuPont, BP Chemicals, BOC, Dow Corning and NWA GmbH.

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For further information contact Prof. Martyn Poliakoff or Dr. Steve Howdle, the School of Chemistry, University ofNottingham (http://www.nottingham.ac.uk/supercritical/)

Liquid Effluent Treatment Research and Development at BNFL, Sellafield

(G.V. Hutson, British Nuclear Fuels, Sellafield Research and Development, Cumbria, England)'

Introduction

The objective of liquid waste management for the reprocessing of nuclear fuel is to reduce, by best practical means and as far as reasonably practicable, the quantity of activity discharged to the environment. This is achieved by converting the maximum reasonable proportion of wastes into solid form suitable for longterm disposal. A balance must be maintained among activity discharged, secondary waste generated, and costs incurred.

Over 99% of all activity from reprocessing is already routed to the vitrification plant, with virtually all the rest eventually routed to cementation. BNFL is engaged in significant research and evaluation for reducing even further the already small discharges. It is essential that the active species removed should be reasonably converted to a form which can be fed to encapsulation plants, without materially compromising the form or significantly increasing the volume of the encapsulated waste. In following this policy it can be seen that BNFL has been remarkably successful in reducing its liquid effluent discharges and dose to the critical group, that is, those members of the public most exposed to the marine discharges (see Figures 1 and 2).

The current position

The current liquid effluent treatment procedures carried out at Sellafield can be seen from the simplified flow diagram, Figure 3.

Pond effluent

Magnox fuel arriving on the Sellafield site is storedunder water in ponds prior to decanning. Effluents from decanning and the pond water are treated with a natural ion exchange material, monitored, andifwithin prescribed limits, discharged to sea. The used ion-exchange material and sludge material from pond storage are held in store for future treatment and cementation. The solid waste from decanning has historically been storedunder water for future recovery and cementation. Current arisings are now directed straight to cementation together with some retrieved swarf.

Highly active effluent

The reprocessing solvent extraction process is designed to separate the vast majority of the fission products and unwanted transuranics from the reusable uranium and plutonium. This highly active (HA) effluent is evaporated to reduce the volume and stored for a number of years to allow decay of the short-lived isotopes. This material is now being converted into solid glass blocks for long-term storage.

Medium active effluent

Medium active (MA) effluents arise from the separation and purification of the reprocessing products, uranium and plutonium. The effluents are not suitable for HA evaporation because of either the relatively highvolume or the chemistry of the liquors. These streams are therefore directed to MA evaporation and subsequent storage of the concentrated material.

Prior to 1980, the concentrates were stored for at least three years to allow for decay of the short-lived isotopes, which made up most of the active inventory, before controlled discharge to sea within prescribed limits. Since the early 1980s, in line with BNFL's policy to reduce discharges where practicable, these concentrates have been retained on site until the development and construction of a new treatment plant. This new enhanced actinide removal plant (EARP) began active decommissioning in 1994 and is progressively treating the backlog of stored MA concentrate as well as current arising following a suitable decay period.

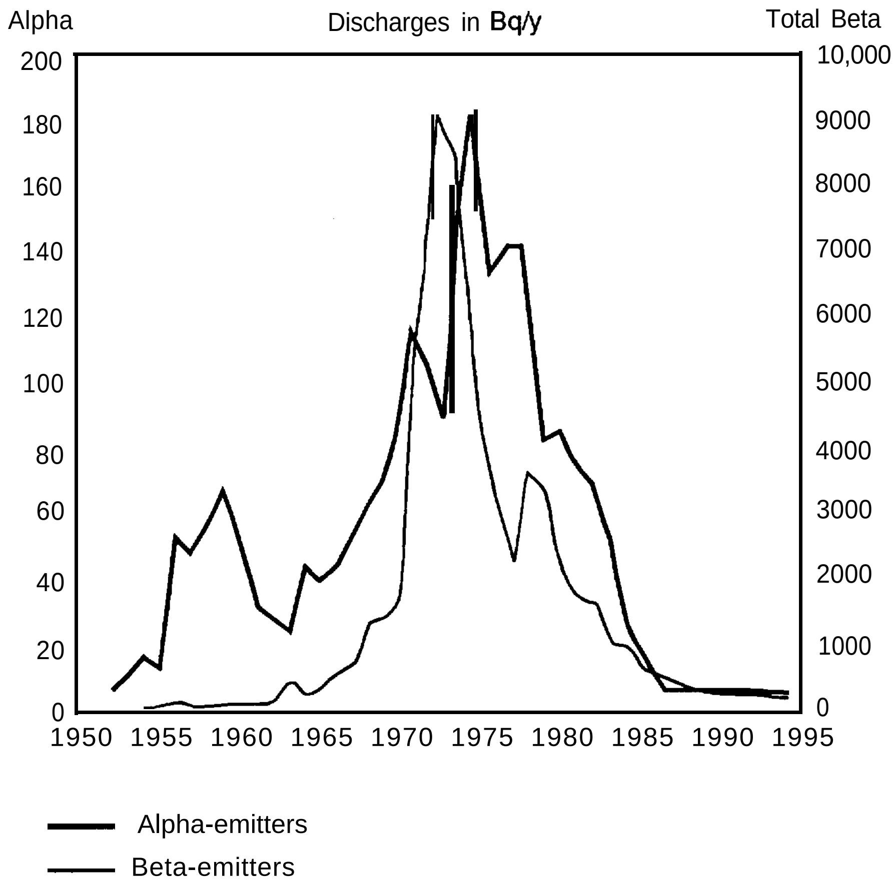

Figure 1. Discharges of alpha- and total beta-emitters in liquid effluent from Sellafield.

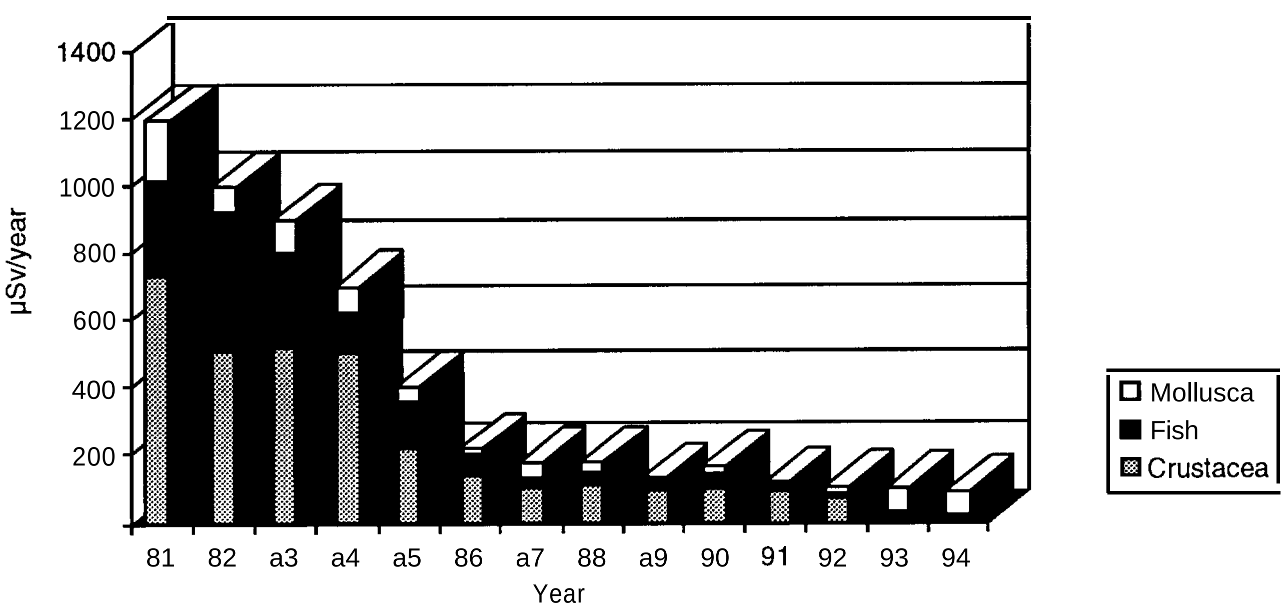

Figure 2. Dose to seafood consumers from Sellafield discharges (1995 perspective)

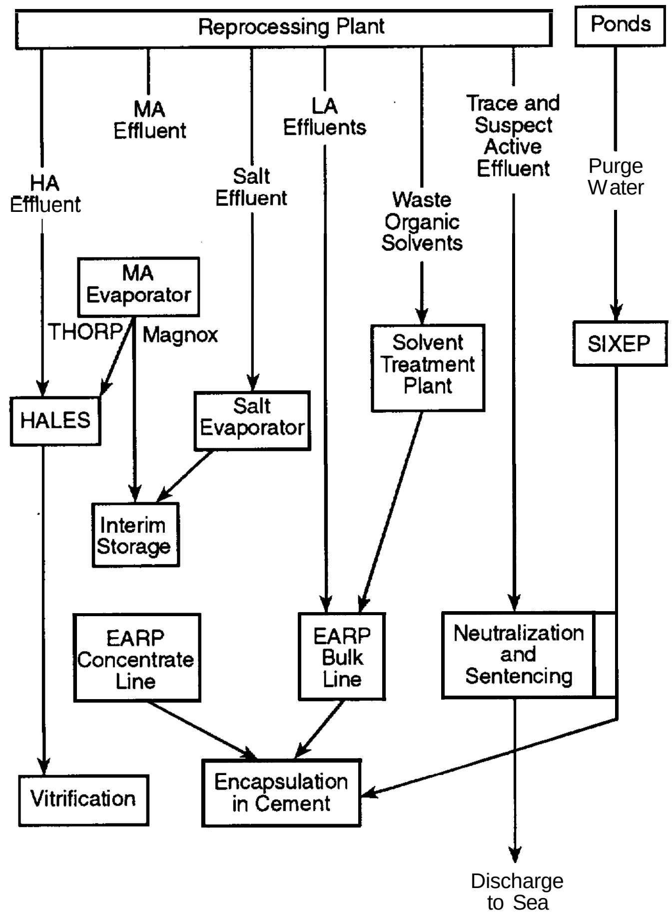

Figure 3. Liquid effluent treatment scheme, Sellafield site (HALES = highly active liquor evaporation and storage plant).

This plant uses precipitation to remove the bulk of the radioactive species onto a solid floc which is concentrated and dewatered by ultrafiltration before being encapsulated in cement for long-term storage. Trace quantities of activity remaining in solution are monitored and discharged to sea (Ivens, 1990).

Salt effluents

The reprocessing operationuses extraction with an organic solvent which becomes contaminated. In order to minimize waste solvent arisings, this material is chemically washed and recycled into the process. The aqueous arisings from the washing are high in sodium salts which prevent evaporation along with MA effluents, because they only have a low concentration factor.

From 1985, this material has been routed to a purpose-built salt evaporator and the resulting salt evaporator concentrate (SEC) has been stored to allow decay of short-lived isotopes prior to treatment in EARP.

The backlog of SEC, as well as current decay-stored arisings, will be treated along with the medium active concentrate (MAC) against a defined programme over a long period of time. Like MAC, it is converted into a cementitious product for storage.

Low active effluent

The remaining low active (LA) effluents are streams which are unsuitable for evaporation or ion exchange due to chemical composition, high volume or low activity. The combined LA effluents have in the past been neutralized and discharged to sea. However, as part of the design for EARP, the more active LA effluents have been segregated onto a new drain system and routed to a chemical precipitation in EARP. The resulting floc with most of the activity is cemented and stored for future disposal.

The EARP bulk process, as this treatment is known, began active commissioning in 1994 and is now in full successful operation, treating more of the LA effluent with a resulting further reduction in sea discharges.

Trace active effluent

These remaining effluents are not suitable for treatment in EARP because of chemical compatibility or very low activity concentration, The effluents will continue to be conditioned by neutralization and sentenced for controlled discharge to sea, with insignificant environmental impact.

Waste organic solvent

Although solvent is recycled for reuse in the processing operation, a small volume is transferred into the effluent streams because of radiolytic degradation, solubility and process characteristics. Solvent remaining as a free phase in the effluents is collected into storage tanks for future treatment.

A new solvent treatment plant (STP) is under construction to treat this solvent by washing, hydrolysis and combustion. This plant was expected to begin operation in 1998 and will treat current arisings and recover the existing backlog of stored material.

Significant differences between effluents generated by reprocessing of oxide and metal fuel

The above processes were developed essentially as adjuncts to the Magnox reprocessing plant, operated since 1964 with successive improvements, The need to minimize waste arisings of all kinds was a major influence on the design of the new reprocessing plant for oxide fuel, THORP.

One important limitation on waste treatment in the older plant is the use of ferrous sulphamate as the reductant in the separation of plutonium; this leaves levels of salts in the waste stream, which are major contributors to the waste volumes generated. In the new plant, ferrous sulphamate is replaced by U(IV) stabilized with hydrazine, not strictly a salt-free reductant but leaving no metal ions in the residue, since the uranium follows the product stream. This allows the MA evaporator concentrate to be fed into the HA evaporator (Figure 3).

Hence, an even greater proportion of the active waste isotopes can now be concentrated and subsequently vitrified.

In fact the only major liquid effluent from oxide fuel reprocessing which is not eventually vitrified, are the raffinates from solvent washing, which, because no satisfactory replacement has yet been found for sodium carbonate and sodium hydroxide, are not suitable for vitrification because of the their high sodium content. Hence they have to be fed to a salt evaporator and subsequently EARP, as do those from metal fuel reprocessing.

The bulk of water from the THORP cooling ponds does not require ion-exchange treatment to remove activity before discharge. This is because corrosion of the stainless steel or Zircaloy cladding on oxide fuel is much less than that of Magnox alloy, and the spread of any contamination is limited by intermediate containers. However, a small quantity of boronated water from the inner containers used to transport some of the oxide fuel from the power stations to Sellafield is fed to EARP and the pond water is filtered to remove any spilled oxide fuel, to sensibly minimize discharges.

The future

Even with the enormous reduction in radioactivity discharged in the last 20 years, BNFL still maintains a significant research and development (R&D) programme in the area, with the following objectives:

To help minimize discharges from future plants.

To treat efficiently new effluent arisings, for example from decontamination and decommissioning of redundant plants, using existing facilities wherever possible.

To cost-effectively reduce discharges from existing operations.

To keep abreast of current knowledge, national and international, and to review its applicability to Sellafield.

To achieve these aims the BNFL effluent research programme is divided into four categories.

(a) Increasing scientific understanding of BNFL's existing plants with a view to increased efficiency, both in terms of economic performance and activity discharged.

(b) More generic research, aimed so that the appropriate technology is applied in any future plant that BNFL may wish to build at Sellafield or elsewhere.

(c) Truly generic research, which, whilst not specifically targeted at effluent treatment, may have value in this area.

(d) Information gathering.

(i) Proactive membership of appropriate nuclear and chemical industry 'expert working groups,' including those promoted by the International Atomic Energy Agency (IAEA) and the UK chemical industry.

(ii) Participation in appropriate national and international conferences.

(ii) Direct contacts with other major players in appropriate fields, including the US National Laboratories.

Before describing the BNFL research programme, it is relevant to quote from a recent IAEA Technical Report (IAEA, 1994).

> 'The main purpose of liquid waste management is to minimise the radiation exposure to both workers and the public, including the long term effects, When considering a waste treatment process a number of factors affect the choice, with economic considerations being very important. Capital and operational costs, plus the cost of disposing of secondary wastes need to be minimised. The need for improved decontamination at low cost led to new or specific processes for waste streams being examined and developed. '

This report identifies technologies in which it recommends further research should be pursued, acknowledging that for a considerable number of effluent streams, more than one process will be required. In the BNFL Sellafield context, the technologies are as follows.

Chemicalprecipitation

This process has been widely used and tested and is a mature technology. The scope for fundamental improvement to the basic precipitation process is limited. However, there is potential for specific reagents to enhance the decontamination factors for certain nuclides, and also for improvement to the subsequent solid/liquid separation. For the future, chemical precipitation will probably remain an important part of combined processes. Developments or process adjustments are needed which will be applicable on an industrial scale.

The programme has two main elements, both aimed at improving the efficiency ofthe EARP plant.

(a) Improving the removal of specific nuclides such as technetium and strontium which have a low environmental impact, but are nevertheless significant numerical proportions ofthe discharges.

(b) Studying the relationship between the precise chemical environment in which the precipitation occurs and the physical properties ofthe floc produced. This is hoped to allow improvements to the efficiency ofthe processes and subsequent encapsulation in cement.

Ion-exchange process

Developments in this field are likely to be in a number ofareas. Organic ion-exchange shows some promise but there are still the problems ofradiation stability and ultimate disposal, and it is thought that development ofa new organic ion-exchanger would be limited.

Inorganic ion-exchangers show the most promise with the suggestion that encapsulated ion-exchangers and finely divided ion-exchangers combined with cross-flow filtration could be most effective. More extensive characterization of inorganic sorbents is required, and ifcombined with the development of an internationally agreed test to allow objective absorber comparison, this work could be done more quickly.

Inorganic ion exchange has been used extensively at Sellafield to treat Magnox pond water and decanning liquors, mainly for the removal of caesium and strontium. In 1985, BNFL successfully commissioned the site ion exchange plant (SIXEP) which used a naturally occurring inorganic exchange medium (clinoptilolite). This plant has met its design targets and significantly exceeded its planned availability, permitting the treatment ofadditional volumes of effluent such as historic and decommissioning wastes.

With increases in such requirements, further fundamentalunderstanding ofthe use ofclinoptilolite is being developed in order to minimize additional activity discharge to sea.

Areas under study include plant operating parameters, inactive component composition (e.g. calcium, magnesium and sodium) and possible improvement in the quality of clinoptilolite.

Modelling oftheprocess is being studied to facilitate the objective.

The main route for initially evaluating new ion-exchangers and sorbents is by proactive membership ofthe Novel Absorber Evaluation Club (NAEC) which encompasses the whole ofthe UK nuclear industry. It has now evaluated over *40* new, mainly inorganic absorbers and ion-exchangers, although to date none has shown sufficient overall potential improvement over those currently in use at Sellafield to warrant detailed consideration as replacements.

Evaporation

This is a well-known and widely used process to separate a liquid waste into a concentrate containing practically all the involatiles and a highly decontaminated distillate that can be discharged as low or trace-active effluent. Especially with transuranic wastes, the concentrate is intended for geological disposal, so the volume needs to be minimized and inactive salts may have to be destroyed or removed by other means.

The technology is mature and already used extensively at Sellafield. All ofthe evaporators are designed to established and probably conservative models. However, recent developments in evaporation technology are being evaluated for possible application to future requirements.

Membrane processes

These appear most promising in combination with other processes, such as the three previously mentioned. A major area of development will be the control and removal of membrane fouling.

The effects ofprocess conditions, such as feed composition and radiation on operating equipment will need further examination.

Withultrafiltration and microfiltration, the use ofinorganic membranes should be preferred because oftheir wide operational range of pH and temperature and also their radiation resistance.

Inorganic membranes are currently employed in the ultrafiltration stage ofEARP, as the best process to provide excellent solid/liquid separation together with a highly concentrated but still mobile sludge. The modules currently employed are performing at least up to specification, but some work is in progress to investigate alternatives mainly with the aim ofprolonging service life and providing a diversity of supplies.

There is also a significant programme ofwork on the more novel technologies such as supported liquid membranes.

Solvent extraction

This process is generally limited by the large volume of both aqueous and organic secondary waste generated; however, it may have promise in certain limited areas, possibly the use ofsupported liquid membranes and macrocyclic extractants.

The decontamination of evaporator concentrates by solvent extraction is a promising process, but much more research is required to find good extractants, and if possible, to industrialize the use of liquid membrane techniques which reduce the volume oforganic solvents necessary. Special developments are needed to solve the problem ofmembrane stability and to increase the kinetics of extraction.

Solvent extraction is the essential heart ofreprocessing and both the Magnox and THORP flowsheets separate the waste products into streams compatible with effluent treatment, so that a considerable depth of knowledge on the topic exists within BNFL. The assessment of novel solvent extractants is part ofthe company generic research programme. Any options relevant to reducing liquid effluent discharges would be subjected to more detailed investigations.

Biologicalprocesses

The use ofmicrobiological processes for liquid effluent treatment was investigated in considerable depth in the mid- 1980s as part of a process selection exercise for both EARP and STP. In both cases, a microbiological system was found which performed the basic function (e.g. removed activity for EARP and degraded solvent for

STP) but the resultant spent biomass was so heavily contaminated with activity and other toxic species that it was more difficult to treat than the original effluent. The processes also presented many engineering problems.

Clearly, microbiological processing was not sufficiently advanced to be a viable contender for these plants, but in holding considerable future promise, it is another key element in the generic work programme.

Many biopolymers display properties which make them very attractive as candidates for use treating aqueous nuclear waste. Often they carry an electric charge and in some cases the charge density is high. In addition, most biopolymers carry ligand groups.

Electrochemicalprocesses

Substantial R&D over at least the last decade has not led to any significant applications in the nuclear industry, despite many successes elsewhere. The greatest use of electrochemical processes will almost certainly be to enhance other processes such as filtration, osmotic dewatering, ion-exchange, etc. The ultimate role will be not only to remove radioactive contaminants from non-active material, but also in procedures to decompose material to its component chemicals, possibly for recycling.

Electrochemical processes are always subject to fouling ofboth membranes and electrodes by impurities. Any process must therefore be tailored to a particular waste stream.

BNFL has evaluated the use of an electrical cell to deposit technetium on the anode, and after scoping trials on simulated liquor showed promise, trials were performed at Sellafield using actual medium active concentrate which had been passed through the EARP miniature active pilot plant. Basically, these very simple trials showed some promise. Although there are still some concerns (on the possible rapid re-dissolution ofthe technetium and co-deposition of other species), this process might be applied to the reduction of $^{99}T_c$ discharges generated in the treatment ofbacklog MAC.

Organic waste

Processes are established to destroy the major spent solvents, but not yet established for relatively low concentrations of complexing agents, such as citric acid and ethylene diamine tetraacetic acid, which are often present in aqueous effluents and hinder their disposal. There is also a requirement to destroy some bulk organic liquids such as laboratory wastes and scintillation fluids.

Oils might simply be encapsulated. Alternatively, the most promising process appears to be some form of oxidation, probably in a combination ofmodes such as catalytic chemical oxidation or photo-oxidation, possibly enhanced by electrical means.

For the soluble organics, the main thrust is in oxidative technologies to destroy their complexing ability and hence allow direction of spent decontamination solutions to existing effluent plants such as EARP.

Overview

Requirements ofthe nuclear industry are not surprisingly similar to those in other process industries, as demonstrated by a process recommended for further R&D in the hydrometallurgy industry (Anthony and Flell, 1994).

Clean technology

An integral part ofthe R&D programme is to continue the philosophy, already clearly demonstrated in the flowsheet changes from metal to oxide fuel reprocessing plants, ofreducing or eliminating effluent and other waste arisings wherever this is practicable. To this end, effluent treatment and waste management experts are involved in the early stages of process evaluation for all new plants BNFL is contemplating.

Conclusions

BNFL has reviewed developments in technology and techniques in the treatment of liquid effluents and is at the forefront of development and application of processes. Potential treatment processes have been summarized; many of them are employed at Sellafield and the possibility of extending their use is under constant consideration.

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An Overview of the QUESTOR Research Centre
(Jim Swindall, Queen's University, Belfast)

Prof. Jim Swindell gave a complete overview of the Queen's University Environmental Science and Technology Research Centre (QUESTOR) and emphasized that it is based on the concept of industry and academia working together to protect our shared environment.

QUESTOR is carefully structured on industrial and academic cooperation. It focuses on industry driven research which is interdisciplinary. Research is conducted in the areas of chemistry, chemical engineering, civil engineering, computer science, agriculture, microbiology, and psychology.

All of the research undertaken has an environmental theme and it is generic. This is important given that research is selected based on whether it will give value to all ofthe industrial partners. Also, the research carried out is basic and pre-competitive.

Prof. Swindell thengave a briefoverview ofthe history ofthe Centre. In 1986, Prof. Swindell identified an urgent need for research funding. In light ofthis he applied to the International Fund for Ireland (IFI) for funding and began visiting industries to sell the concept ofindustrial and academic co-operative research. At this time he was strongly supported by the U. S. National Science Foundation. In 1988, a planning meeting was organized in Belfast and from this, nine companies tentatively agreed to support the Centre. A research plan was prepared and the companies were encouraged to revise this based on their individual needs, It is this element ofthe overall approach which proved hugely successful; industry is encouraged to take ownership ofthe research conducted at the Centre and this leads to much stronger involvement and support for QUESTOR.

In 1989, QUESTORwas founded. Since then, theCentre has grown steadily and enjoys continual success. In 1992, QUESTOR received a STRIDE grant to improve the Centre's infrastructure; in 1995, a Technology Development Project (TDP) grant facilitated the building of a clean laboratory; in 1996, an application for a large IF1 grant was successful; and in 1997, the Centre won the Queen's Anniversary Prize. The QUESTOR Centre. was officially opened by Prince Charles in 1997.

QUESTOR operates in the following manner. The Industrial Advisory Board (IAB) meets every six months. A call for research projects is issued and the results writtenup in six monthly reports which are circulated to the various industrial members for review prior to the IAB meeting. At the IAB meeting, the industrial members prioritize the proposed research projects as a group. Each industrial partner enters into a formal agreement with the University and there are special provisions governing patent rights and publications. In terms offinances, the money contributed by industry acts as a lever to bring in additional grant aid. Good management is essential given the success of the Centre is based on continued efficiency. A final crucial element ofthe operation is the fact that it undergoes continual independent evaluation by agencies such as the U. S. Environmental Protection Agency which gives QUESTORinternational credibility.

The original focus of QUESTOR was on end-of-pipe technology, cleanup technology, and emissions modeling, but this has expanded into the development of clean technologies under the TDP and IF1 funding programs. The TDP funding is worth £2.74 million over 3-5 years and focuses on developing clean technologies and installing demonstrations in small to medium sized enterprises (SMEs). The IFI funding is worth £1.05 million over 4 years and involves building an interdisciplinary outreach team to install demonstrations onclean technologies in SMEs.

The benefits of QUESTOR for Queen's University include increased research links with industry, enhanced opportunities for leveraging other sources of funding, increased input from industry into the postgraduate training process, the ability to attract quality postgraduate students, the provision of a focus and mechanism for interdisciplinary research, and finally, improved international links.

The benefits of QUESTOR for industry include cost-effective participation in an £11 million industry-related environmental researchprogramme, direct input into the research strategy of the Centre, opportunities for recruitment, increased technology transfer, increased contact with University staff, access to international databases, and finally, opportunities for networking.

QUESTOR is now in the enviable position of being able to stop recruiting industries because the Centre has reached its optimum size. Prof. Swindell issued a word ofwarningregarding growth, if the Centre grows too quickly, industry will leave because they will have less participation.

In summary, QUESTOR is an industry-led research facility which is internationally recognized and continually building upon its successes. It owes its success to its unique capability for industry-university co-operation. QUESTOR is participating in technology transfer to SMEs and in the retention and expansion of the industrial base in Northern Ireland. QUESTOR is unique in the European Union and is involved in cleanup technology and technical communication with large and small companies in pure and applied research.

Prof. Swindell closed by emphasizing that the term QUESTOR was chosen with due care; in fact the meaning of the word is one who seeks and searches and this is the underlying essence and mission of the Centre.

Life-Cycle-Engineering as a Tool to Develop and Promote Clean Products & Processes and the Cleaner Production Internet System in Germany

(Matthias Finkbeiner, GmbH, and Horst Pohle, Federal Environmental Agency, Germany)

Life-Cycle-Engineering

Dr. Matthias Finkbeiner of GmbH began the German presentation with a discussion of life-cycle-engineering (LCE) which investigates the technical, environmental and economical aspects of products and technologies. LCE therefore aims to include all relevant oftechnical, economical and environmental information in a single decision-supporting management tool. All relevant information must be available within the design phase of products or systems as soon as possible, in order to arrive at the best informed decisions. The basis for all decisions should be the whole life cycle ofa product in order to avoid tradeoffs.

LCE is a simulation tool to analyse the weak points and optimization potentials as well as to support product and technology development. It changes the "snap-shot" character ofLife Cycle Assessment (LCA) to a flexible tool which enables predictions about product and technology developments.

Development of Clean Products and Processes

With regard to design for the environment (DfE), Figure 1 shows the relation between cost responsibility and cost initiation within the complete research and development (R&D) phase of technical products. It easily can be demonstrated that the design has avery high degree ofcost responsibility, compared to the small influence in the production phase. Opposite to that the main cost initiation takes place in the production, whereas the R&D expenditures are relatively small. This finding canbe transferred to environmental considerations. Parallelto the cost responsibility, the design mainly influences the environmental profile ofa product. Emissions occur during the production, use and recycling/disposal ofthe product but the decision has been made earlier. However, with LCE design, decisions can be supported, because quantitative information ofproduction processes is used to model the expected performance of alternative design options.

Promotion of Clean Products and Processes

With regard to product or process comparisons, Figure 2 shows that a single-value comparison of an existing technology with an innovative technology can be meaningless. Ifthe singlevalue for the current technology

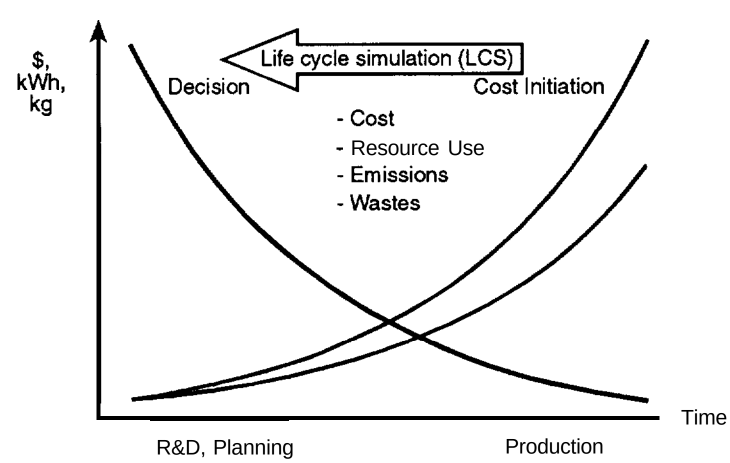


Figure 1. Life cycle engineering as tool for design for environment.

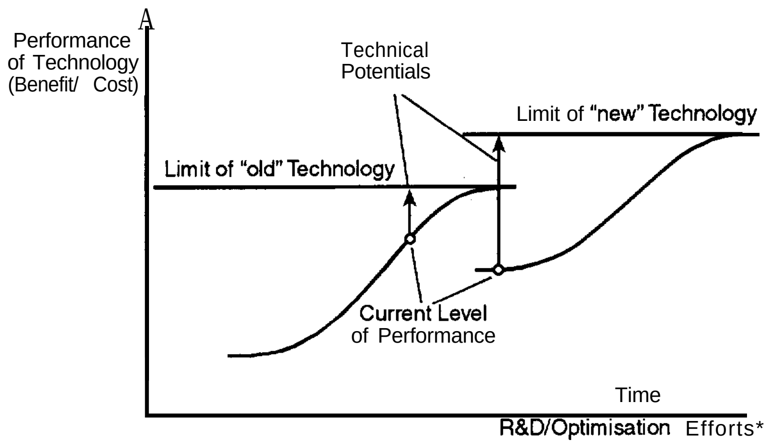


Figure 2. Time dependence of technology performance.

levels is chosen, the "old" technology might be better, because it is already optimized. However, the "new" technology will be much better, if some further development is achieved. Therefore, if LCA is used to assist decision-making by comparisons, LCE can be applied to obtain a more comprehensive result. Many innovative and clean products or processes lack immediate competitiveness, either from their actual performance or just from mis-perception in the marketplace. LCE can provide quantitative information on the potentials of these technologies. Long-term investments can be promoted, especially if an economically and environmentally viable break even of "old" and "new" technologies can be shown.

German Cleaner Production Internet System

Dr. Horst Pohle of the German Federal Environmental Agency, discussed the proposal for sharing information on environmental technology/cleaner production in Germany at the end of 1999 via the Internet. The Intenet system has a "clearinghouse-function" for special partners with a lot of primary information. The system will give information on the results of different "cleaner production projects." In addition, information will be available on all CP-actors and their activities in the fields of investigation, environmental technology hardware, and economics. A separate element of the system will focus on environmental technology transfer outside Germany. The system will be offered in German and English.

Canadian Cleaner Production Activities
(Adrian Steenkamer Jr., Environment Canada)

Mr. Adrian Steenkamer gave a detailed review of Canadian activities in the area of cleaner production (CP). UNEP defines CP as a preventative sustainable strategy applied to processes, products, and services focusing on the conservation of raw materials and energy, the elimination of toxic materials before they leave a process, the reduction ofenvironmental impacts along the entire life cycle of products, and the incorporation of environmental concerns into designs and delivery of services.

The objectives of the Canadian strategy are to entrench the cleaner production/pollution prevention philosophy into the everyday decision making process of Canadians, to promote and advance the application of cleaner production by industry, and to inform Canadians about the opportunities and benefits of new and innovative CP technologies.

National drivers of the strategy include the 1992 Federal Environmental Stewardship Program, the 1995 Sustainable Development Strategy, the 1995 Federal Pollution Prevention Strategy, the Canadian Environmental Protection Act, and the Fisheries Act, amongst others.

The major Canadian players include: Environment Canada which is trying to make sustainable development a reality in Canada by helping Canadians live and prosper in an environment that needs to be protected, respected and conserved; Industry Canada which hopes to help make Canada more competitive in a knowledge-based economy; the National Research Council of Canada which hopes to develop an innovative, knowledge-based economy through science and technology; and, Natural Resources Canada which hopes to provide the knowledge and expertise for the sustainable development of Canada's natural resources and ensure the global competitiveness of resource and related sectors for the well-being ofpresent and future generations of Canadians.

Regarding working groups and roundtables, Canada is participating in two national pollution prevention working groups (P2C2 and ECP2 Team) to ensure the federal house is in order and to lead by example. Internationally, Environment Canada is participating in two roundtables including the European Cleaner Production Roundtable and the U.S. National Pollution Prevention Roundtable. Canada is also developing a national CP stakeholder working group to identify strategic research and development opportunities.

Regarding biotechnology applications, Mr. Steenkamer confirmed that biotechnology continues to develop as a clean technology, based on its attractiveness as a low cost, low energy and labour intensive and renewable technological solution to long standing environmental problems within the pulp and paper, energy, chemical, textile, and food processing industries.

The Panel on Energy Research and Development (PERD) is the only federal interdepartmental R&D fund focused on the non-nuclear energy sector and its economic and environmental impacts. It has five specific tasks: Task 1 focuses on energy efficiency, Task 2 on energy and climate change, Task 3 on transportation, Task 4 on renewable energy sources, and Task 5 on hydrocarbons,

Technology Partnerships Canada (TPC) invests in projects that foster international competitiveness, innovation, and commercialization, as well as increased investment in Canada. TPC has invested in Ballard Power Systems Inc., which is developing a PEM (proton exchange membrane) fuel cell which produces electricity efficiently, without combustion, by combining fuel with oxygen from air; Iogen Corp. who are involved in the development and production of ethanol for powering motor vehicles from biomass such as farm waste products (straw, oat hulls, etc.); Maratek Environmental Technologies which has a recycling process for the printing industry that reduces inorganic and organic pollutants by 95% and cuts water consumption by 90%; and, GFI Control Systems Inc. with Ford Motor Company to produce bi-fuel natural gas and bi-fuel propane powered vehicles.

The objective ofthe Industrial Research Assistance Program (IRAP) is to help Canadian small and medium-sized enterprises (SMEs) create and adopt innovative technologies that yield new products, create high qualityjobs and make industry more competitive. They achieve this by providing technical and innovative-related advice and information to SMEs; linking clients with enterprise, facilities and resources; providing funding to stimulate innovation in Canadian SMEs; incorporating design for environment into all new projects; demonstrating an eco-efficiency innovation pilot; and showcasing Canadian products.

The Technology Early Action Measures (TEAM) support technology deployment and development in support ofearly action to reduce greenhouse gas (GHG) emissions nationally and internationally, while sustaining economic and social development. TEAM works with Canadian industry to reduce GHGs by supporting and implementing community-based GHG technologies. TEAM also is transferring Canadian GHG technologies to other countries.

The IS0 14000 Series is a series of standards documents which will enable governments and organizations to create or improve comprehensive environmental management systems (EMS) to help them achieve their environmental goals and policies. This series supports Canadian Council of Ministers of the Environment's (CCME's) 1996 strategy on pollution prevention by responding to CCME priorities, represents an efficient and cost-effective approach, and promotes proactive and voluntary action.

Environment Canada's use of EMS started in 1995 based on the IS0 14000 standard. It now uses a departmental team approach using approximately 4,500 employees. It is organized around 23 "environmental aspects" (e.g. energy conservation) and 13 facility and site categories (e.g. laboratories) with approximately 7,500 Environment Canada sites. There is departmental implementation and maintenance through an organizational business planning and reporting cycle, i.e. accountability. Also, there is a systematic process for continually improving environmental performance ofits facilities and operations.

Regarding international activities, Canada is participating in an information exchange on environmental technology (APEC-VC-Canada, US EPA International Cleaner Production Cooperative); preparing to sign the UN International Declaration on cleaner production in Vancouver, in April, 1999 (originally presented at the Korean Cleaner Production Conference in 1998); helping Uruguay, Argentina, and Chile through the Canada-Southern Cone Environmental Technology Initiative (CANSCET); and holds several international Memorandums ofUnderstanding (MOUs) with China, Poland, India and others.

Mr. Steenkamer finished by emphasizing that Canada intends to continue to develop cleaner production technologies in the future through established funding mechanisms to enhance Canada's dissemination ofnew and innovative technologies within its borders and to increase the exchange of information on developing cleaner production technologies with other countries.

Reed Bed Treatment of Wastewater From Chemical Industries

(Susete Martins Dias, Institut Superior Tecnico, Portugal)

Most of the processes involved in organic synthesis in the petrochemical and the pharmaceutical sectors discharge two different types of effluents, one ofthemwith a high concentration of organic contaminants and the other of low strength. The former should be treated to recover the main contaminant products, physical-chemical unit operations being used. This treatment also produces an aqueous stream with low concentrations oforganics.

Levels of organicsup to 100-l 50 ppmin these effluents are not easily removed because there is not enough driving force for using physical-chemical processes. The application ofbiological processes is hindered by the toxicity and recalcitrancy ofthese compounds. To overcome this situation reed bed technology may be used to take advantage ofthe biological and physical-chemical interactions within the reed bed.

Several steps in the removal mechanism within reed beds are already known. Focusing on the biological ones it may be noted that two main steps occur, firstly the debranching ofmolecules and secondly, the opening of aromatic rings. Therefore, in the treatment ofnitrogen aromatic compounds, high levels ofammonium, nitrite and nitrate may appear which will require using processes involving denitrification as a final treatment step. This denitrification can also take place in reed beds even for effluent with high nitrogen levels, providedan external carbon source is supplied.

The reed bed can itselfbe considered as a clean process, as there are no wastes produced such as sludges. In principle, the grown biomass should be cut every Autumn and it is possible to use it as a fuel.

Promoting Good Practice in Northern Ireland and Great Britain: Help for Sustainable Waste Management (through Waste Reduction/Clean Technology)
(Nigel Carr, Environment and Heritage Service, Belfast, Northern Ireland, United Kingdom)

Dr. Nigel Carr outlined the work being carried out by the Industrial Research and Technology Unit (IRTU) to encourage waste minimisation and clean technology in industry in Northern Ireland and Great Britain.

In the modem world no one can afford to ignore the effect that growth and technological progress can have on the environment. Every industry, business and individual has an impact - through the energy they use, the materials they consume and the waste they generate. The processing of waste for reuse has significant environmental benefits including the conservation of non-renewable resources and the reduction ofpollution. However, businesses are typically more concerned with competitiveness than conservation. But "being economic" means "not being wasteful." Recycling can, at least for pre-consumer waste, have financial benefits. The body of this talk gives specific examples where benefits from recycling have been realized by local companies.

New measures are taxing business for the disposal of waste and penalizing them more severely for unauthorised pollution. The role of IRTU is to encourage companies to be more competitive by focusing on environmental management. To get the message across, IRTU publishes *Point*, a magazine which focuses on the environment and business. This is issued three times per year, circulated to over 6000 businesses and focuses on key environmental and business topics including: increasingly stringent legislation; rising disposal costs; and, the fact that environmental management makes good commercial sense.

The starting point for many companies is an environmental audit perhaps with a longer term view to the introduction of a structured system by which practical results will be achieved over an extended period of time. A successful audit will have the commitment of top management and the leadership and resources to carry it through. The majority ofcompanies which fully commit themselves to an audit frequently do not have the expertise withintheir organizations to undertake such a review. Financial assistance is available through the Environmental Audit Support Scheme which will contribute two thirds of the cost of the audit, Further financial support is available to those who wish to obtain the recognition which accompanies an environmental management system (EMS). There were approximately 130 applications for EMS by March 1999, 22 of which have attained IS0 1400 1.

IRTU published a number of case studies in this area in November, 1994. There are 14 local success stories which include savings of £100,000 per year, income of £50,000/yr, payback occurring in one year; and effluent charges reduced by 37%. Dr. Carr outlined three of these success stories.

Dromona Quality Foods in Cookstown employs 120 people in manufacturing cheeses and a range of dried milk products, Changes implemented in the company included the segregation of raw materials, waste management and recycling, centrally treated effluent, and a reduction of phosphate levels through alternative detergent use. Less water is now extracted for the plant and less effluent discharged.

Tayto in Tangragee produces potato crisps with starch as a by-product leading to increased suspended solids and COD. The waste is now recovered with a centrifuge and the waste product sold.

Farm Fed Chickens in Coleraine processes 250,000 chickens per week. They werefaced with discharge bills of £13,000/month, and they installed a treatment plant for £ 120,000 which reduced themonthly effluent costs to £3,500 and, with running costs, the pay back will be less than 18 months.

There are 24,000 people working in the textile industry and it has a turnover of £1 billion. In an Environmental Technology Best Practice Programme (ETPBPP) survey, 1146 companies were asked how many saw no benefit from improving environmental performance; 37% oftextile companies surveyed saw no significant cost benefits inimproving environmental performance. As a consequence, technical clubs have been established within the textiles, food, and metal finishing sectors. These encourage collaborative action on the environment.

This was the objective of the WEFT (Waste Elimination From Textiles) project. Techniques and opportunities identified for waste minimisation include: good housekeeping, process changes (statistical quality control, closed loop systems, clean procedures); raw material changes, re-use/recycle (e.g., solvents, process water, metals, plastics), technology changes (substitute mechanical for chemical); and product innovation (new uses for rejects and waste streams).

Dr. Carr then outlined the response of several textile companies in Northern Ireland.

Clendinnings is a commission printer of furnishing fabrics and household textiles. Their processes all require water and chemicals which, after use, produce effluent. When the Department of Energy advised that continued discharges would add £170,000 to the Company's costs, Clendinnings reviewed their water and chemical usage. The problem lay in excessive water and chemical usage resulting in high costs. The solution lay in reducing water and chemical consumption. The result was savings of £1 00,000/yr for the company without compromising quality or technical standards.

Desmond and Sons, one of Northern Ireland's largest privately owned companies, manufactures around 100,000 garments each week at two of its factories in Omagh and Newbuildings. To achieve the popular 'washed' look for the denims, these two factories use approximately 180,000 gallons of water daily. Desmonds have now introduced a heat recovery system whichuses the hot wastewater to preheat incoming cold washwater to within 5 °C of the required temperature. The company expects the heat recovery system to make savings of around £85,000 per annum.

Ulster Carpets, carpet manufacturers, have recently modified their finishing process to make more efficient use of raw material resources to reduce the environmental impact of their effluent waste steam. The carpets were finished in a batch process where foamed latex is applied to the back of the carpet. At the end of each day, small amounts of latex invariably remain in the application tank. Typically 13 litres per day of foamed latex required treatment prior to discharge. A special pump was purchased to transfer the residual latex to a sealed holding tank. This simple modification preserved the latex and prevented contaminationuntil it could be reintroduced to the next day's batch. Ulster Carpets saved over £16,000 in the first year against costs of £1,000 for the pump and £2,000 for implementation which gives a payback of 12 weeks.

Ambler of Ballyclare produce yarns for the industrial knitting sector. A systematic approach was applied to their waste. Polythene bags used for packing individual cones of yarn were eliminated without affecting quality, giving savings of £32,000 /yr. The use ofpre-printed cones saved £8,500 /yr. These two measures had no capital cost and gaveimmediate paybacks. Conventional cardboard boxes were replaced by large, collapsible, reuseable cartons which reduced purchasing, transport and handling costs. Anew baler for waste materials produced more compact bales and so reduced disposal costs. To ease re-use and recycling, waste is segregated by staff as it is generated. Markets have been established for the re-use of sacking from incoming fibre and for the recycling off ET strapping/polythene sheeting fromincoming fibre bales and ofcardboard and paper packaging. The sale of these materials nets Ambler around £l,800 /yr. Installationand operating costs amounted to £55,667. Net savings were

247,335 in year 1 and £103,000 in subsequent years. Combined payback on all the measures taken is less than 7 months.

The examples above are of local companies who have benefited from addressing aspects of their waste production. For other companies, dealing with waste is a central pillar of their business activities. These businesses focus on recycling waste from companies other than their own. This often constitutes off-specification materials and worn out products. Many waste types can be dealt with in this way and while the recyclers invariably specialise in a single waste type, most common materials (e.g., paper, glass and plastic) are catered for. The latest issue of *Point* includes 11 categories with approximately 47 companies.

The ETPBPP was launched in June, 1994 to increase competitiveness through the best environmental technology with themes of waste minimisation and cost-effective cleaner technology. The program focuses on waste minimisation, and solvent use, in the foundry industry, textile industry, paper and board manufacturing industry, glass industry, and metal finishing industry. There are numerous ETBPP published guides and case studies on waste and water minimisation, on cleaner technology and on reducing solvent waste. There are numerous guides and case studies for the following industries including: paper and board, printing, foundries, glass, textiles, metal finishing, chemical, ceramics, and food and drink. All these are available to companies to enable them to see the benefits of improving their environmental performance.

Cleaner Production in Lithuania
(Jurgis Staniskis, Kaunas University of Technology)

Cleaner production (CP) activities started in Lithuanian in 1992. These were based on the private initiative of specialists from the Institute of Environmental Engineering (APINI) and foreign donors, The Pollution Prevention Centre (PPC), based on a co-operation agreement with the World Environment Centre (WEC), USA, was founded at APINI in April 1994. PPC is a non-profit nongovernmental organisation promoting sustainable development, cleaner production/pollution prevention/waste minimisation in Lithuanian industry and other spheres of the economy. The establishment of PPC in APINI was part of the international program of USAID activities in the Baltic countries.

The PPC Mission Statement is:

Kaunas PPC will become the primary centre in Lithuania for providing industrial sectors with relevant research, technical consulting assistance and training on various environmental subjects (e.g., EMS) and critical management skills (e.g. for problem solving and raisingfunds), all with the ultimate goal of introducing cleaner production techniques, preventingpollution, andachieving economic savings. These industry aimed services will be supplemented by educational efforts for related governmental organisations, NGOs and academia.

The PPC isplaying a key role in disseminating and expanding CP programs in the broadest sense nationally and regionally. First of all, its staff have extensive practical experience and training in CP, EMS and financial intermediary consultancy, which makes them well placed to organise and lead CP programs and projects. Secondly, it has good links to the network of CP experts and business organisations, both nationally and internationally. Thirdly PPC has credibility and acts as independent intermediaries among different stakeholders including enterprises, universities, industrial associations, government ministries, etc. The PPC has developed a realistic business plan specifying services which they could provide to clients, including enterprises, universities, government and donors.

PPC services and activities according to the business plan developed in 1996/97 are the following:

Technical assistance (CP/waste minimization opportunity assessment, research, laboratory services, etc.)

Environmental management (training, auditing, consultancy in EMS and standards, certification, etc.)

Financial intermediary (training in "financial engineering," preparation ofbankable projects and loan applications, projects monitoring and supervision, projects progress report, etc.)

Education (courses on CP and EMS for undergraduate and postgraduate students, co-ordination of PhD studies in environmental engineering, etc.)

The PPC experts in 1998 have developed the National Program for Cleaner Production and Environmental Industry Development, which will be approved by the Lithuanian Government in 1999.

It should be emphasised that a relatively new activity of PPC is as financial intermediary in the scheme "Nordic Environmental Finance Corporation (NEFCO) - PPC - Company - PPC - NEFCO." The PPC plays a crucial role in this scheme performing:

Preparation of loan applications on behalf ofapplicants, according to NEFCO's format for cleaner production;

Assistance in the calculation ofcost savings constituting the basis for the estimated pay back time ofthe planned investment and requested maturity oftheloan; information on the applicant's financial status supported by audited financial statements (translating)

Assistance in communication with the applicant and preparationofloan documentation

Assistance in project monitoring and supervision, including supervisionofthe procurement process and project implementation progress as compared to budgets and implementation plan as well as project objectives

Preparation of project progress and completion reports to be presented as part of the borrower's disbursement requests.

To date, 15 Lithuanian companies' proposals prepared under PPC guidance have been approved by NEFCO.

Experiences in practical work in industries during waste minimisation projects in 100 companies show that lack ofreliableinformation about the material streams at the production lines causes difficulties in the collection of information and preparation ofmass balances, In most cases those difficulties are conditioned bythe shortage of necessary measurement equipment to identify water and streams of various substances in the manufacturing process. The result is that many potentially interesting options for waste minimisation might be perceived as unfeasible. For the purpose ofhelping industrialists to work with pollution prevention/waste minimisation problems, the environmental laboratory at PPC was established in April 1998. This is a powerful tool in disseminating cleaner technologies among Lithuanian industries. The selection ofequipment is determined by the main purpose ofthe laboratory, which is the practical implementation ofthe waste minimisation approach and related research.

Four international conferences were arranged by PPC in the period of 1994- 1998 :

The UNEP Invitational Expert Seminar "Introducing Cleaner Production inEastern Europe," Kaunas, APINI, September 22-23, 1994.

International Workshop on "Waste Minimisation in the Food Industry," Kaunas, APINI, March 20-23, 1995.

The First Meeting of a Network of Cleaner Production/ Pollution Prevention/ Energy Efficiency Centres in Central and Eastern Europe, Kaunas, APINI, April 23-25, 1997.

The International workshop on "Environmental Management Systems and Standards," Kaunas, APINI, September 17-18,1998.

The PPC initiated and, together with Vytautas Magnus University, Lithuanian Agricultural University, Klaipdda University, Vilnius University, Lithuanian Energy Institute and Engineering Ecology Association, started to publish a scientific quarterly journal entitled "Environmental Research, Engineering and Management" in Lithuanian and English languages in 1995.

Regarding the Lithuanian CP network, PPC has representatives in different parts of Lithuania, and has very good contacts and relationships with different international donors, financial institutions, and international organisations, for example, OECD, UNEP, WBCSD, UNIDO, INEM, USEPA and others.

Types of waste minimisation activities implemented are outlined below:

Waste Minimisation Activity Type	*Number of Projects*	*Investments, Lt*	*Savings, Lt*
Process control improvement	3	341,280	149,939
Equipment modification	8	60,374	167,454
Material recycle	6	89,417	540,660
Change in operating practice	2	205,000	295,100
Process modification	1	203,000	213,536
Raw material substitution	2	6,220	10,677
Heat recovery	6	1,837,074	3,253,152
Total:	28	2,742,395	4, 630,518

A summary of the project entitled Implementation of Cleaner Production Projects in Lithuanian in Textile Industry (LIFE, 95/Project LT/B2/LT/875/BLT) is given below:

The primary objective of this technical assistance project is to foster the practical implementation of CP practices in 8 selected textile companies in Lithuania and contribute to the dissemination and implementation of such CP practices throughout the Lithuanian textile industry.

The first objective was to create 8 examples of the successful implementation of CP projects in textile companies; the local experts will assist the companies in identifying, evaluating and implementing appropriate CP practices. These factors normally constitute the breeding ground for ongoing environmental improvements. Project implementation efforts will be focused on no-cost and low-cost opportunities.

The second objective was to coach 18 Lithuanian experts (12 from companies, 6 from academia) in CP auditing in the textile industry; in the framework of this project, these experts in the participating companies were conducting the audits and were implementing the demonstration projects. After finalisation of the project, these experts will become keyplayers in the dissemination and implementation of CP practices in the Lithuanian textile industry.

The CP audits undertaken in this project were based on the application of a preventive environmental strategy for manufacturing and production processes. Normally, such CP options belonged to one (or a combination) of the following prevention techniques:

product modification: modification of the product characteristics in order to minimize waste and emission generation in the manufacturing process or in order to reduce waste and emission generation during the product use and disposal;

input substitution : substitution ofinput materials (dyestuffs, auxiliaries and chemicals) in order to minimise the volume and/or toxicity ofwaste streams and emissions from the production process;

technology modification: optimisation, or redesign and replacement, ofthe equipment in order to reduce waste and emission generation or to reduce material, water and/or energy consumption;

good housekeeping: organisational, motivational and managerial provisions in order to avoid, or at least minimise, waste and emission generation;

on-site recycling: re-use, recycling and/or recovery of wasted materials at the same production location.

Besides their contribution to environmental improvement, practices like those outlined above often improve the economic position of the company by: minimising the waste and emission treatment and disposal costs; minimising input ofmaterial costs (energy, dyestuffs, auxiliaries, chemicals and water); and improvement ofproduct quality.

The contractor is the Ministry ofEconomics of the Republic ofLithuania and the Project partners are the Institute of Environmental Engineering, Kaunas University of Technology, IVAM Environmental Research, University of Amsterdam

The list of the main CP programs and projects performed by PPC and foreign partners in the period of 1993-1998:

Waste Minimisation Opportunity Audits to Introduce Cleaner Technologies in Lithuanian Industry (1993-l 995) Partners: Rendan AS (Denmark), Lund University (Sweden); 8 companies

Waste Minimization Demonstration Projects Implementation in Chemical industry (1993-1996) *Partners:* World Environmental Centre (WEC, USA); 6 companies

The First Norwegian-Lithuanian Cleaner Production Training Program (1995- 1996) *Partners:* World Cleaner Production Society (Norway); 14 companies

Implementation of Cleaner Production in Lithuanian Tanneries (1996-1998) Partners: Chemcontrol AS (Denmark), UAB "Ecobalt" (Lithuania); 5 companies

Implementation of Cleaner Production Project in Lithuanian Textile Industry (19961998) *Partners:* IVAM, University ofAmsterdam (The Netherlands); 8 companies

The Second Norwegian-Lithuanian Cleaner Production Training Program (19971998) Partners: World Cleaner Production Society (Norway), Det Norske Veritas (Norway); 14 companies

Cleaner Production Dissemination Seminars in NIS (Armenia Azerbaij an, Kyrgystan, Kazahkstan, Moldova) (1997); *Partners:* OECD, ERM (UK)

The Project Cleaner Production Centre Networking in CEECs - Experience Transfer and Development Assistance (1998); Partners: Regional Environmental Centre (REC), Czech Cleaner Production Centre.

The Third Norwegian-Lithuanian Cleaner Production Training Program (1998-l 999) *Partners:* World Cleaner Production Society (Norway), Det Norske Veritas (Norway); 15 companies

Financing of Cleaner Production Projects (1998 - 2000) (11 Lithuanian companies at the time being). Partners: Nordic Environmental Finance Corporation (NEFCO)

The Demand for Environmental Technologies, Services and their Providers (1997 - 1998). Partner: The Regional Environmental Centre for Central and Eastern Europe

Capacity Building in Environmental Auditing in Lithuania (1998 - 1999). Partners: Det Norske Veritas @NV), 13 Lithuanian companies

To Strengthen the Framework and Administration of Lithuanian Laws on Waste Management and on Environmental Management of Industry (1997-1999). *Partners:* COWI, Miljokemi (Denmark); 6 companies

Environmental Due Diligence Training of EBRDs Financial Intermediaries (1999). *Partners:* Jacobsen Engineering LtD., UK; 2 Lithuanian Banks

Implementation of Cleaner Technology in Lithuanian Slaughter Houses (1998-2000). *Partners:* COWI, (Denmark) COWI Baltic (Lithuania); 8 companies

A Ukrainian's Version of a Systems Approach to Sustainable Development in Environmentally Damaged Areas: Cleaner Production and Industrial Symbiosis as Major Ways to Pollution Prevention

(William M. Zadorsky, Ukrainian State University of Chemical Technology)

This presentation outlines the concept of a systems approach to the problems of ecological damage, on the way to sustainable development, taking, as a case in point, Ukraine.

According to the official statistics, Ukraine is considered to be one of the most ecologically damaged countries in Europe. Ukrainian Parliament has declared the entire territory of the country a zone of ecological disaster. It's the result ofthoughtless, hasty andill-considered short-run decisions. Leaders of all levels didn't bother themselves to think much of how their conclusions would affect the future. Man-provoked, man-made transformation and contamination of the environment have reflected back on man himself. As medical statistics show, health of the population has suffered significant changes and only for the worse. The environment influences everyone without exception.

If we want to survive, it is inadmissible to remain under conditions which obviously run counter to survival. In other words, according to the sustainable development concept, we must not compromise the health of future generations. It is well-known that, while the present generation may be able to survive contaminated conditions, there may still be disastrous reproductive perils, leading to severe handicaps in children, grandchildren, great-grandchildren, and so on into the future.

Lester Brown of the Worldwatch Institute gives a simple and comprehensive definition: "A sustainable society is one that satisfies its needs without diminishing the prospects of future generations." The question is how can we achieve this stage in the ecologically damaged zones and can we achieve it at all ?

Some scholars in these cases believe that it may be necessary to evacuate populations to safer areas and attempt to restore damaged homelands employing volunteers or protected workers. Ukrainian specialists are searching for other paths to prevent people from having to flee for their lives. The defensive concept of nature and population protection in Ukraine is now replaced by the new one, the basis of which is not only transformation, ecologization (reduction of environmental loads), sustainable development of agriculture and industrial complexes, but adaptation and rehabilitation of populations.

The system analysis of a complex system "humankind- nature- economy" shows that for human survival, it is necessary to combine ecologization ofindustrial and agricultural manufacture simultaneously with human adaptation and increasing immunity to conditions of life in ecologically adverse conditions.

As regards social solutions, a program ofadaptation and rehabilitation of the populationis developing for the first time in Ukraine, and the concept may be used for any technogenous intense region. Features of the program are integration ofefforts of joint activity in the spheres of science, engineering, training and management for the purpose of solving the problems ofpreventive maintenance, adaptation and rehabilitation of the population in worsened ecological conditions.

Integrated efforts permit the passage from dangerous concepts not only to analysis oftechnogenous activity effects, but to vigorous reduction of environmental loads - ecologization (including CP, WM, P2, LCA) of manufacture and creation of conditions for adaptation of a system to major technological effect.

For along time all of us stood up for wasteless technology; then we were convinced, that strictly speaking, this does not happen. Then so hotly we have taken a great deal of interest in various concepts, in particular mathematical modeling and optimization (MM), functional - cost analysis (FCA), including in ecology; then by theory of acceptance of the decisions (Solutions Theory - ST); ecological management (EM); and, in particular, waste management- WM (the last concepts have found brilliant realization in IS01 4000). At last, the concepts of cleaner production (CP), sustainable development (SD) and LCA have appeared.

From my point of view, it is dangerous, that the supporters of each concept consider it as a panacea and try with its help to solve both global and local tasks. A second danger is our enthusiasm for the fashionable approaches - leaving constructivisms for the area of "talkative ecology." I state a point of view of man who has come to a conclusion: fashionable currents are within the framework of one method, overlooked per last years: system analysis or approach, ingenious interpretation of which became the concept of sustainable development.

I am not going to state the basis of system analysis, for, I do not doubt, you well know it, but I want to address only two of its aspects, which are necessary for further statement.

Hierarchy (collateral subordination) of systems ("hierarchy" -literally is translated "sacred authority") on a vertical assumes inter-subordination and interference (direct and opposite), interrelation of levels ofhierarchy of various scale (subsystems and oversystems).

Thus each subsystem can be examined in two faces - as a subsystem for a superincumbent level ofhierarchy and as an oversystem for an undelying one.

Two aspects of the system approach are shown in Table 1.

Hierarchy of Systems and Concepts

Vertical hierarchy implies that any subsystem of a system may be regarded either as a lower-level system in relation to the upper tier or as an upper-level system for the lower tier.

There should be a match between a tier in a hierarchy and the methodology of characterization, assessment or influence used at this tier. This aspect does not seem to have been sufficiently covered previously and deserves a closer look. The tools used to analyze, study and influence an object should match the respective tier dimensions and frequency of magnitude.

Table 1. Hierarchy of Systems and Concepts

Tier	System	Frequency order	Dimension order, m	Concepts and methodologies for the tier
1	Man-nature-technology	$0.1\ hr^{-1}$	10^7	SD
2	Consumption sector	1 month-' to 1 yr^{-1}	10^4	SD, LCA, MM, FCA, ST
3	Manufacturing	$0.001-0.01\ s^{-1}$	10^2	SD, EM, MM, FCA, ST, LCA, P2
4	Plant	$0.01-0.1\ s^{-1}$	10	MM, P2
5	Plant item	0.1-I s^{-1}	1	SD, WFT, MM, ST, P2
6	Apparatus or machine	I-I $0^4\ s^{-1}$	1	MM
7	Work assembly	I-I $0^4\ s^{-1}$	$10^{-3}...10^{-6}$	MM
8	Molecular level	$10^5...10^8\ s^{-1}$	1 0-Q ... 10^{-12}	Physics, chemistry

A measuring tape would not do for measurement and quantitative evaluation of a phenomenon at a molecular level. Low-frequency oscillations will not affect kinetics ofprocesses at this level. Similarly, LCA can hardly contribute to understanding ofprivate lives ofmolecules. An elephant cannot be expected to feel the prick ofa needle, for the needle size ismuch smaller than that ofthe elephant's nerve endings. Likewise, LCAwill not help much in changing a manufacturing process because the object and the method of characterization differ in the dimensional scale.

All the methods and approaches, more or less recent, should be ordered so that each one finds its own place. Let us take another look at the table. Within thehierarchy framework (although other structures are naturally thinkable), it is possible to arrange the methods and concepts as shown in the extreme right column. It should be noted that the tiers have fuzzy boundaries and therefore some methods are applicable to more than one level.

As regards LCA, the systems dialectic teaches that a new system must nucleate within the old one while the latter still exists. In the case at hand, waste recycling should be regarded from this standpoint. For example, LCA may help identify wastes that can be reused and/or recycled, e.g. via industrial symbiosis. But it is difficult to use LCA as a scientific method ofknowledge ofintimatelife ofmolecules at this hierarchicallevel. And it is impossible with the help LCAto change the processing ofthis or that production. Scales of object and method ofimpact here do not coincide.

Differently, we shall try to spread out all methods, the concepts and approaches on the shelves and then all will fall into place. Let's address once againthe table. Within the framework ofthe accepted hierarchical ladder, the decomposition ofmethods and concepts shown on the right is possible. Note that a rigid border between levels is not present, which means some methods can work at two and more levels.

Based on these reasonings it is possible to formulate some concrete offers ofpossible participation ofthe experts ofUkraine in theNATO/CCMS Clean Products and Processes Pilot Study by development ofthe above concepts of system analysis and, its practical and constructive aspects.

First of all, it is a databank on methods of influence on systems at various hierarchical tiers for purposes of ecologization (this Russian termini integrates CP, EM, WM, P2, LCA). The methods included inthe bank have passed industrial tests and/or areused in industrial conditions. Some ofthe methods are little known in the West and are offered forjoint development, for example:

Non-conventional methods ofreduction of environmental loads:

Recirculating flow ofthe least hazardous agent taken in excess over its stoichiometric value;

Controlled heterogenization ofthe contacting phases for softer conditions and improved selectivity;

Separative reactions: removal of reaction products at the moment oftheir formation;

Synthesis and separationin an aerosol to increase intraparticle pressure and reaction rate;

Self-excited oscillation ofreacting phase flows at frequencies and amplitudes matching those at the rate-limiting tiers ofthe system;

Flexible synthesis systems and adaptive equipment to embody them;

Process engineering for high throughput to cut processing time and reduce byproducts and wastes; and

Industrial symbiosis as a basis for management of secondary materials and energy.

Commercialized environmentally friendly technologies, which were found highly competitive in:

Synthesis of-

alpha-lecithin, ammonia fluoride, bromine, bromine-derivative flame-retardants, bromomethyl chlorosilanes, coccidin, cyacrin, dimethylacetamide, dimethylformamide, 1,4-dioxane, germanium, itaconic acid, permetrine, meta-phenylenediamine, pyrocatechin tetrabutoxysilane, and tetrabutoxytitanium.

Impregnation processes of-

carbon/graphite materials, porous metal electrodes, capacitors, catalysts, cloths, electric rotors, paper, wood, etc.

Removal of submicron particles from gases or liquid.

I myselfused to enthuse over many ofthe concepts formerly as fashionable as LCA seems to be now. My belief is that all of them are aspects of one technique now partly forgotten. I mean the system approach that culminated in the concept of sustainable development.

And at last some words about the CP movement (only my point ofview). What might help the CP movement meet its goals worldwide:

1. Clear terms and definitions
2. General theory, strategy, and tactics
3. Economic mechanisms stimulating transition to CP technologies
4. Association, coordination and information oforganizations and individuals dealing with CP
5. Network of regional and national CP centers
6. University training and continuing education in CP

What might help the CP movement meet its goals in transition economies:

1. Methodology for application of CP philosophy to restructuring, military conversion, privatization and economic transition at a national or regional level
2. Practicable program for embodying the CP concept under sweeping changes in the NIS and other transition economies
3. Restructuring, privatization and military conversion in relationship to building an environmentally friendly economy
4. Priority-based investment programs for attracting investors to NIS

The cornerstone ofthe concept is ecoliteracy. Only true knowledge, awareness and aconsequent shift in our perceptions, our thinking, our values, our behaviour and our attitude to everything surrounding us will make it possible to build a sustainable society.

R&D for Clean Products and Processes in Japan
(Ryuichiro Kurane, National Institute of Bioscience and Human Technology, Japan)

Dr. Ryuichiro Kurane began his presentation by outlining the bottlenecks that hinder the establishment of clean industrial products and processes and consequently sustainable industrial development. Hurdles blocking the establishment of new concepts and strategies for environmentally friendly industrial products and processes must be identified. It is important to discuss the future potential ofR&D developments and new opportunities including how policies should bemanaged to promote public and private efforts to develop new technologies in biotechnology for industrial sustainable development. Tables 1 and 2 outline bottlenecks to the development ofnovel bioproducts and bioprocesses.

The life cycle concept is important. The concept ofminimizing total energy consumption during an entire industrial process from sourcing of raw materials to disposal of finished,products is also considered to be quite useful. Also important is the concept ofdesigning products and processes taking into consideration the impacts they have on the environment including human health and the disposal offinished products. This "total energy and cost concept" focuses on preventing post-use and post-disposal impacts through biotechnology to minimize the costs of restoring the quality of the environment (bioremediation costs). These strategies would make a significant contribution to the development ofenvironmentally benign produts and processes.

Environmental impacts occur at all stages ofa life cycle. Design can be employed to reduce these impacts by changing the quantities and types ofmaterialsused in products, by creating more efficiently designed products, and by reducing materials during waste management as shown in biodegradable plastics and biopolymers. For biotechnology R&D that concentrates on bioprevention, clean design conceptswill play important roles.

Biopolymer (bioflocculant and bioabsorbent) produced by microorganisms and also organic solvent tolerant microorganisms were discussed by Dr. Kurane. Microorganisms producing microbial flocculent include: *Rhodococcus erythropolis, Nocardia restricta, Nocardia calcarea, Nocardia rhodnii, Corynebacterium sp., Alcaligenes cupidus, Alcaligenes latus, Pseudomonasjluorescens, Pseudomonas cepacia, Acinetobacter sp., Enterobacter sp., Agrobacterium sp., Aureobacterium sp., Oerskovia sp.*

Dr. Kurane went on to outline the water absorption capacities ofvarious absorbents. Those in the test group included sucrose and fructose bioabsorbent samples which were produced using different culture conditions i.e., by changing the culture medium's carbon sources. The water absorption capacity per gram ofdried sample for each of these samples was 1,349.0 and 1,295.4 g respectively. The control group consisted of various absorbents including a high-grade synthetic high-polymer absorbent (polyacrylate/PVA derivative) and an aniomicsynthetic high-polymer absorbent (polyacrylamide derivative). While the water absorption capacity was higher for these samples compared to others in the control group they were much lower than the values for the test samples. Dr. Kurane then discussed the water absorption capacities ofbioabsorbent and synthetic highpolymer water absorbent in various sodium chloride concentrations. As the NaCl concentration increased from 0 to 2.5%, the water absorption capacity ofthe bioabsorbent reduced from 1,439 to 376, and the synthetic highpolymer water absorbent from 249 to 24.

Constituent sugars of the bioabsorbent include glucose, rhamnose, fucose, and glucuronic acid and identification methods include TLC (Thin-layer Chromatography), HPLC (High-Performance Liquid Chromatography), GC (Gas Chromatography), and GC/MS (Gas Chromatography/Mass Spectroscopy).

Dr. Kurane completed his presentation by outlining the following trends in, and potentials of, science and technology:

The development ofclean products and processes is influenced by public demand, market pull, and scientific and technological feasibility.

Among the emerging science and technological discoveries that present major opportunities for developing clean biotechnological products and processes are improved and novel biocatalysts, bioconsotium-based systems, pathway engineering, and bioinformatics.

The introduction ofbiotechnology into many industrial processes will be increasingly dependent on the development ofrecombinant biocatalysts.

Bioprocessing engineering and integrated bioprocessing also remain as critical factors for the commercialisation ofbiotechnology

Various technical bottlenecks need to be overcome through R&D in order to increase biotechnology's penetrationinto industry.

Demonstration projects are vital for bridging the gap between laboratory biotechnological research and industrial implementation.

Table 1. Bottlenecks to the Development of Novel Bioproducts

Product Innovations	Bottlenecks	Potential Solutions
Green commodities: biodegradable plastics, polymers, biofuels	Renewable resources, cheap fossil fuels, scale-up	Biomaterials and biofuels as alternatives to petrochemistry
Recycled products	Dilute organic wastes, recalcitrant wastes	Value-added products
Substitute products:	R&D	Nanomachines
microelectronic devices	Production scale-up	Biochips
crop protection agents	Resistance, specificity and persistence	Biopesticides, plant growth enhancers
Biomaterials		
- inorganic (magnetic, composite, complex architectures)	Natural resource depletion, bioprocess development	Biomimeticslbimoecular templates
- organic (spider silks)	Factory farming	Fermentation technology, recombinant DNA technology

Table 2. Bottlenecks to the Development of Novel Bioprocesses

Process Elements	Bottlenecks	Potential Solutions
Biocatalysis	Susceptibility to: organic solvents, heat, acids, alkalis, pressure, toxic hydrophilic substrates	Extremophiles, biodiversity search and discovery, biocatalyst immobilisation
	Catalytic properties: short half-life, too specific, chirality	Directed evolution, protein engineering, reaction conditions
	Multi-step reactions	Bioconsortium processes, pathway engineering
	Novelty: lack of biocatalytic analogues of chemical catalysts	Hybrid enzymes, ribozymes, abzymes
Bioprocessing engineering	Bioreactor innovation: monitoring/control	Biosensors, fuzzy logic control (artificial neural networks)
	Microaqueous systems	Membrane reactors
	High and low reactant concentrations	Process intensification, biocatalyst development
	Animal/plant cell cultures	Control of apoptosis, elicitation, signal transduction
	Downstream processing: separation, purification	Integrated bioprocessing

Cleaner Production /Pollution Prevention in Polish Industry
(Andrzej Doniec, Pollution Prevention Center, Technical University of Lodz)

Environmental regulations in Poland are in the course of adjustment to European standards. A new environmental act which takes into account European Union directives is in preparation. Irrespective of these future regulations, existing regulations are conducive to the promotion of environmentally friendly industrial processes. However, at this time there are few incentives to initiate a broad use of cleaner production principles.

The Polish State Environmental Policy of 199 1 introduced the principle of source pollution prevention. The document states that in the long term (25-30 years) employment of environmentally friendly production processes will be compulsory, and that clean technologies would be preferable.

The cleaner production/pollution prevention concept came to Poland through relevant foreign programs (Norwegian, Danish, American). The Norwegian-Polish cleaner production program established in the framework of the United Nations Environmental Program (UNEP) resulted in some hundreds of people trained and numerous different scale projects incorporating production process improvements. The activity of foreign organizations in spreading an environmentally sound approach in production processes has also been economically advantageous.

A major contribution to cleaner production in Poland has been made by the World Environmental Center (WEC) in New York. WEC, acting with financial support from the United States Agency for International Development, conducted several waste minimization programs designed for different industrial branches (i.e. chemical, nonferrous metallurgy, dairy and meat industries, etc.). Eighty-two projects accomplished in thirty-eight plants resulted in a savings of over 3 3 million PLN per year (about $9 million).

As a part of its activity, WEC has established three Pollution Prevention Centers (PPCs) in Poland. The PPC at the Technical University of Lodz endeavours to promote the idea of environmental friendly production and products through seminars and conferences on appropriate topics (e.g. Clean Technologies in the Organic Coatings Industry, November 1998), direct site activities (e.g. electroplating facilities), publishing source and informative materials (e.g. a Polish translation of the WEC Waste Minimization Manual), and research in the area of ecodesign/ eco-product (recycling of electrical and electronic equipment).

A number of other achievements in the field of cleaner production have also taken place in Poland as well. For example, several major chemical companies in Poland have joined the Chemical Manufacturers Association's Responsible Care Program. In addition, single initiatives were undertaken in the recycling area (batteries, plastic bottles, light tubes, cars).

Despite the progress and achievements in cleaner production, there are barriers to cleaner production born from economic, sociological, and psychological issues. These circumstances result in the sustainable product idea existing poorly in the minds of managers and decision makers, as well as society in general, Barriers to cleaner production include: thinking of environmental protection as end-of-pipe treatment; a lack of understanding of the necessity of integrating pollution prevention by local authorities; the poor financial conditions of companies fighting for survival; the belief that only large sums of money can improve the environmental performance of a company; and lack of involvement of lower rank personnel in solving current problems.

There is hope, however, that new regulations currently under development will be a stimulating factor for cleaner production processes once they come into effect.

Preventing Pollution, the U.S. Approach
(Subhas K. Sikdar)

Toxics Release Inventory (TRI) data that industry report to the Environmental Protection Agency (EPA) have become the most important measure ofcleanliness ofiidustrial operations in the United States. Over time, most industrial sectors, the food processing industry for instance being an exception, have shown a dramatic decrease in TRI emissions, indicating that the combined effect ofregulatory enforcement, citizens action, and industry's own initiative have shown results. Despite these decreases, which in relative terms must indicate improvement in environmental quality, industrial operations still have scope for further improvement. There are several reasons for this conclusion. First, the volumes of these TRI discharges are still very large. Second, much of the decrease represents either deep well injection or the useoflegitimate destruction or stabilization technologies, and hence cannot be viewed as preventing pollution vis-a-vis managing it. Third, the TRI data are mass-based; the relative toxicity or hazards are not reflected.

In last year's tour de table presentation Dr. Sikdar discussed the broad spectrum of strategic planning, programs, initiatives, or campaigns that industry, federal and state governments have embarkedupon to develop, evaluate and use environmentally preferable products and processes (please see 1998 annual report, NATO Report Number 230, EPA/600/R-98/065, June 1998, page 60). He also briefly looked at the four categories of scientific and technological activities that make up the U. S. efforts in stimulating cleaner manufacturing that produce, emit, and discharge less wastes. These four categories are: modeling tools, technology tools, sector-specific industrial development, and clean technology demonstration and verification. In this presentation he focused on the strategic aspects of how these efforts are brought to bear in making a difference.

U.S. government sector activities cover three government agencies: the Department of Energy (DOE), the Department of Defence (DOD), and the EPA. The DOE, in its Industries of the Future program has focused on the most polluting industries. Most of these industry sectors, such as petroleum refining, primary metals, glass and steel making are large scale. The goal here is to work collaboratively with industry and formulate an industry roadmap to cleaner productionoperations. This matches EPA's interests and consequently, EPA supports DOE initiatives as discussed by Mr. Divone.

The DOD was sheltered from environmental legislation but recently it has fallen under EPA jurisdiction. Cleaner products and processes being explored in DOD industries include the production ofgreenbullets and green submarines; toxics substitution; and VOC avoidance.

U.S. EPA has a different focus these days which includes the prevention of human toxicity through ecosystems protection and watershed-based environmental management. This involves creating decision making tools to assist in making watersheds more sustainable. EPA has recently formulated a sector-specific pollution prevention program that allows industry to fashion its own environmental program which leads to a reduced overall environmental impact while enjoying freedom to design specific elements ofmanufacturing operations without the regulatory rigors that exist today. This approach, emanating from the earlier Common Sense Initiative, allows a systems thinking on a whole process or a site.

A strong emphasis of other EPA programs is on small- and medium-sized companies that cannot afford research and development and hence would likely not espouse cleaner operations on their own. The Agency has funded development of several pollution prevention assessment tools. Some of these tools help companies to examine the environmental impact of their operations and lead them to choosing cleaner alternatives. Other tools provide estimates ofparameters to evaluate environmental persistence, partition in soil, or biodegradability of products. Still others offer guidance on the relationship between structures of organic compounds and their environmental impacts. These tools are distributed free of charge and in many instances some hand-holding is also carried out.

The continued use of regulatory and enforcement actions conducted primarily by the U. S. EPA targets transportation fuels to decrease SO_x, NO_x, tropospheric ozone, particulates, benzene, and MTBE; residual pesticides in fruits and vegetables; and mercury emissions from coal-fired power plants, and medical and municipal incinerators. Mercury is but one of many persistent bioaccumulative toxic compounds that are being looked at by the Agency. A large-scale screening program has been initiated in collaboration with industry to identify endocrine disruptors -hormone mimicking substances -that citizens are exposed to on a daily basis. Regulations on the use and emissions of some endocrine disruptors are possibilities.

The chemical industry also has developed a 25-year program called Vision 2020 to examine what the industry will be like in 2020, in terms ofmanufacturing, tools, and computation. This industry meets once a year to develop roadmaps and has developed a responsible care program which is a self-governing tool incorporating a code of ethics.

The major strategic theme in these government-funded programs, even in those programs run from a compliance viewpoint, is cooperating with industry, rather than following the old command and control method. The old strategy is seen to have run into a roadblock where only incremental, and not major, improvements are thought possible.

Report on the Status of Clean Products and Processes in Turkey

(Akin Geveci, Marmara Research Centre)

Although Turkey decided in 1995 to organize "cleaner production" (CP) activities from one center, namely the National Cleaner Production Center (NCPC), it could not succeed for many reasons. The most outstanding reason is the lack of authority and nomination ofresponsible parties to manage the activities and to establish the NCPC. Although the promotion of cleaner production is given a big importance in the National Environmental Action Plan (NEAP), neither the Ministry of Environment nor the Ministry of Industry and Trade took any action to fulfil this requirement. The other reason is the lack of appropriate financing mechanisms for the investments.

The disorganized initiations taken by different organizations are listed below.

1. Turkey took part in the Regional Activity Center for CP for Mediterranean Countries program and nominated Marmara Research Center as national focal point. The purpose was to establish a network of Mediterranean Countries to transfer CP technologies from one to another by organizing expert meetings twice a year.

2. A two-year project to promote cleaner production technologies in the textile industry was initiated in 1997 by Marmara Research Center with the financial support obtained from the World Bank (WB) and the Turkish Technology Development Foundation (TDF). CP was applied in six textile manufacturing plants and as a result several application projects were developed and now they are expected to be implemented.

3. TDF is now negotiating with the WB to obtain funds to finance environmental projects especially the CP projects to cover the R&D and the investment expenses.

4. A working group within TUBITAK (The Scientific and Technical Council of Turkey) was formed, working in co-operation with Ministry of Environment, Ministry of Industry and Trade and Ministry of Finance to devise a system to promote CP application.

5. An environmental center has been established in Bursa where textile and leather industries are concentrated to act as a consultant to industry.

Cleaner Production Application in a Sanitary Fittings Producing Plant-A Case History

Company: Eczacibasi Yapi Gerecleri A. S. Artema Armator Grubu Company produces Nickel-Chromium and Copper plated sanitary fittings since 1983.

Environmental Problems: Because the electroplating process was old and a batch system, this caused many environmental pollution problems. These were the excessiveuse ofcleaning and rinsing water and chemicals and wastewater containing excessive amounts of cyanide and heavy metals.

Actions Taken: In 1993 a new fully automated electroplating plant was installed. In this new process cyanide copper plating was eliminated. In plating and degreasing section, solution vapors were collected and discarded to atmosphere after wet filtration. Recirculation water system was also included in fully automatic plating plant. This system cleans the polluted water by means of cation and anion exchange. Clean water from recirculation system is pumped to plating line to be used in rinsing tanks (which are before plating tanks) and polluted water from rinsing tank is collected in recirculation tank to be cleaned and used in plating line again. With this recirculation system and effective cleaning in fully automatic plating line, amount ofwaterused in this system is reduced by 1/6 compared with the old plating plant water consumption.

In 1997, the cleaning tank after chromium plating tank was converted to economy tank and in 1998, the cleaning tank after nickel plating tanks were also converted to economy tank. After this modification, no change was observed in the quality of plated surfaces, whereas the chemicals carried by parts from plating tanks were reduced more than 80%. The amount of waste treated in waste treatment plant went down to minimum and amount of chemical used for waste treatment also decreased.

Figure 1 illustrates a flow diagram of the old and new systems and pollution prevention opportunities.

Conclusions:

-Total cost ofinvestment was 1,924,000 US$ with a financial benefit of 683,000 US$/year.

-Total surface area of plated parts increased by 68%.

-Plated parts quality improved by 80%

-Total waste water treated in waste water treatment plant reduced by the ratio of 1/6 compared with old plating plant waste water amount.

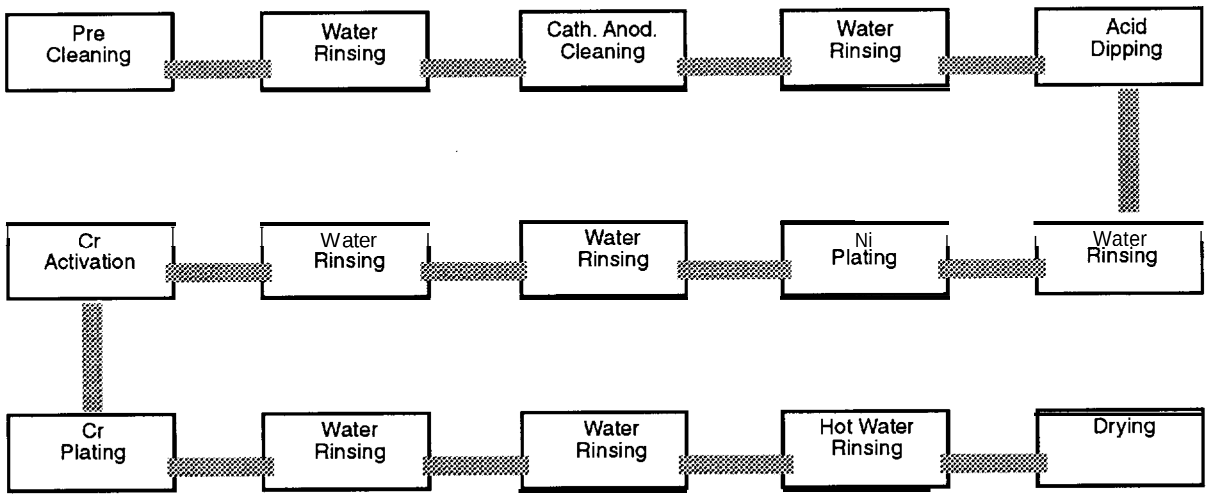
-Total amount ofchemical used in plating plant and waste water treatment section reduced by 50%

-Total amount of waste water sludge reduced by 70%,

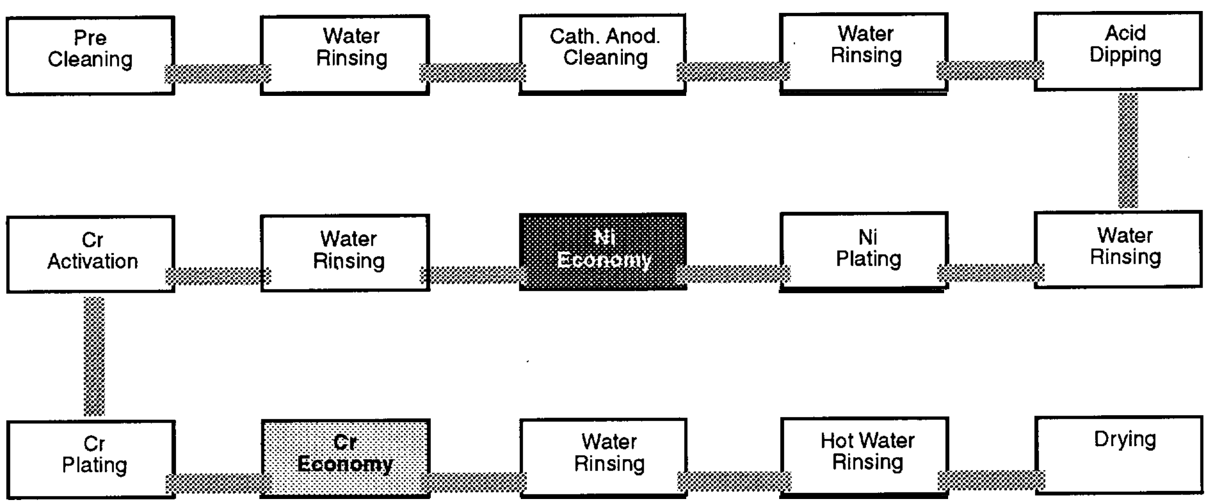
-Cyanide copper plating was eliminated from the plating line because of the risk problem for surroundings and employee,

- Good working condition and surroundings were created, because plating and degreasing solution vapors were collected by push-pull system and thevapors are discharge to atmosphere after wet filtration.

New Plating Line At The Beginning:



New Plating Line After Improvement:



(continued)

Figure 1. (continued)

Pollution Prevention Opportunities:

Pollution Prevention Opportunities	Benefits	cost us $	Fiincial Benefit US %/year	Payback Period
Fully automatic plating plant investment	No cyanide copper plating push-pull system quality, effective water usage, recirculation water system, minimization of chemical usage	1,800,000	590,000	3 year
Filter-press and sludge dryer investment for waste water treatment section	Water content of sludge decreased from more than 80% to less than 65%, water content of dried sludge is Less than 15%.	120,000	50,000	2.4 year
Chrome economy tank addition	Chrome plating solution reuse, minimization of the chromium solution in waste water	2,000	20,000	0.1 year
Nickel economy tank addition	Nickel plating solution reuse, minimization of the nickel	2,000	23,000	0.1 year

Figure 1. Flow diagram of old and new systems

Clean Products and Processes in Israel
(Chaim Forgacs, Ben-Gurion University of the Negev)

Professor Forgacs opened his talk by emphasizing how the "Environment" has become a fashionable buzz word. Consequently, higher education programs have more environmental focus day by day. Education in environmental engineering occurs at two main institutions in Israel; Technion, in Haifa, which is based on the perspective of civil engineering and the Ben-Gurion University in Beer-Sheva which is focused on chemical and process engineering.

In terms ofthe government perspective, there is one Ministry ofthe Environment in Israel which is under budgeted. The majority offunds are expended on supervision activities and granting business licences but there is inadequate funding for investment in the development of new cleaner production (CP) technologies. Therefore, industry is engaged in this activity by themselves as a result of attempting to gain ISO 9000 and IS0 14000 certification. Israeli industries are forced to meet these standards as a result of external pressure exerted by countries to which they export because they want to ensure that Israel is not producing products more cheaply than they can. The results ofthese certification procedures have been positive with small and large industries taking environmental issues seriously.

Fifty percent off srael is desert, therefore fifty percent ofthe country supports the population. The Negev is a desert region where most ofthe chemical industries in Israel are located. The University ofBen-Gurion has made serious efforts to deal with the environmental problems ofthis area particularlywithregard to water and air pollution. Rainfall in this region is limited; therefore the rate ofrecovery ofpolluted media is slow. The municipalities in this region take the problem ofenvironmental pollution seriously. A major concern is clean air and efforts are focused on getting the chemical industry to change their existing practices to repair damage to the environment from past polluting activities.

Examples of Clean Products and Clean Processes

There are many heavy chemical industries in the Negev area including companies producing agricultural chemicals. Many chemical processes involve substitution reactions. In these reactions only a certainamount ofthe reagents end up in the product; the rest ends up in the waste stream. Now, however, this type ofprocess is being replaced with oxyhalogenation. Israel has many industries which produce hydrogen peroxide, thus lowering the price ofhydrogenperoxide, and facilitating the possibility ofusing this in chemical reactions. A mixture ofhalogen and hydrogen peroxide was prepared in the University laboratory and used to reoxidise hydrobromides in an acid bath. One hundred percent ofthe halogen ended up in the final product with no waste. Professor Forgacs suggested that this work has the possibility ofbeing a good pilot project for the program.

Another example ofencouraging clean processes occurred in a city 30 km from the University where two different factories, including a huge textile complex, were convinced to use a joint wastewater treatment plant to enable the waste stream from the textile factory to be recycled

Phosphate mining is also carried out in this area and there are a number offactories producing phospheric acid. The mining industry and chemical factories produce large quantities ofwastewater. A problem arose regarding the disposal ofthis wastewater. This problem was solved by using the wastewater for landscaping (in the desert) and for the recovery of abandoned mines.

A very serious problem regarding elevated levels of sodium chloride exist in the seashore aquifer which is the major source of drinking water in Israel. Instead ofusing ion exchange which can introduce increased sodium chloride into the waste, an improved membrane process is being used which has a 95% recovery rate, so there is no waste discharged to sea.

In closing, Professor Forgacs shared the following anecdotal wisdom. A major chemical factory had scaling in their cooling tower and the suggestion was made to introduce amembrane process to improve the water quality and eliminate the problem; however, when Professor Forgacs visited the plant he discovered that the over-riding immediate problem with the cooling tower was badly corroded piping. As a result the entire corrective action was focused on repairing the pipeline. Professor Forgacs closed by emphasizing that when searching for solutions, engineers should never overlook the obvious.

Clean Processes and Pollution Prevention in Hungary
(Kristof Kozak, Ministry of Environment, Budapest)

Mr. KristofKozak outlined two examples ofthe implementation of clean technology inHungary. The first outlines the introduction of an environmental management system at Petoff Press and the second covers the manufacture of clean products at Etermit Works Ltd.

Environmental performance was one of the key issues at Petoff Press for many years. The company pioneered the introduction of environmental guides in Hungary in 1993. The updated version oftheir guideline was in compliance with ISO 14001 requirements.

The company was already certified for IS0 900 1 and that provided a basis for proceeding to be certified for IS0 14001 as well. The program involved auditing the management, the technological development, and the improvement of certain areas like documentation, purchasing, suppliers qualification, preventative measures, internal audit and training. They expanded upon several documents including a facility environmental impact plan an emergency plan, waste handling guidelines and, last but not least, the company's environmental policy.

During this time the management ofthe company introduced a detailed environmental program that resulted in a significant improvement in their technology. As a result Petoff Press was awarded a certification by the Critical Standards Institution in 1997. One ofthe basic requirements of IS0 14001 is for companies to prove the continuous improvement ofenvironmental performance. To meet this challenge the management is drawing up a list offuture objectives to be achieved in their technological process.

Mr. Kozak then discussed the substitution ofasbestos in products made by Etermit Works Ltd., Hungary. According to the existing EU legislation the use of asbestos fibres in products is severely restricted. By virtue of Directive 76/769 the manufacturing, marketing, and use of crocidolite and other amphybolic asbestos fibres are prohibited. Only crysotil may be used, however it is also banned in several products involving roofing felts. The management ofEtermit Works decided to substitute asbestos in products for roofing and to expand their production in the field ofgardening products.

Mr. Kozak outlinedthe historical background ofthefacility. Theinvention ofasbestos cement sheets was made by Ludwig Hatchel, an Austrian businessman and his first patent was issued in 190 1. He owned an asbestos factory in Austria which employed a simple pulp and paper technology for production. His product, bearing the trade name Eternit, became more and more popular for consumers. Under licence, new facilities were built in Hungary (1902), in Switzerland (1903), in France (1904), in the USA (1905), in Sweden (1906), in Italy (1907) and elsewhere. The Hungarian facility was established as the second within the Austrian-HungarianMonarchy by the River Danube and a railway that connected Budapest and Vienna. This village was at that time dominated by the German population.

After the second world war the factory was denationalised by the People's Republic ofHungary in 1948. The link with the Austrian parent factory was thereby disconnected. Business went on as usual without serious concern regarding the emerging knowledge or the hazardous properties of asbestos. However, crysotil was used exclusively! In conjunction with the transition of Hungarian economy starting in 1989, the property returned to Etermit Werke, of Austria, owned by Fritz Hetschel, grandson of the inventor.

The new management immediately initiated technological development aimed at the protection ofworkers and the environment, During the 1990s they resolved economic problems and expanded their product range by manufacturing flower containers for use outdoors. This product group is manufactured by employing non-asbestos fibres. The underlying technology was provided by the parent Austrian factory.

The management recently made a decision to remove asbestos from manufacturing the two basic product groups, roofing sheets and wave-profile elements, The economical and technical challenges of the decision were assessed by an expert team which made proposals for consecutive steps to be implemented until 2003. The process started last year with the first technical modifications The cost of the project amounts to 2.3 billion HUF. Of that, 60 percent will be covered by the company and the rest is expected to be financed by bank loans and other resources made available by environmental programs and by the public.

Activities at the Research Institute on Membranes and Modeling of Chemical Reactors, Related to Clean Products and Processes
(Enrico Drioli, University of Calabria, Italy)

Professor Enrico Drioli opened his discussion by outlining the structure of Research Institute on Membranes and Modeling of Chemical Reactors (IRMERC) and particularly the scientific council which consists of the director and seven members from different academic institutions and the staff which consists of five senior researchers, two associate researchers and over 15 collaborators consisting of PhD students and visiting researchers. The research programs in progress at IRMERC cover various areas of membrane science and technology including membrane preparation and characterization, transport phenomena in membranes, catalytic membrane reactors, membrane distillation and contactors, integrated membrane operations, membrane processes, membrane in artificial organs, and the molecular dynamics ofmembranes.

The way to solve environmental problems is not to create them. This can be achieved using available technologies such as membrane processes which are cheaper than potential clean-up costs years later.

Membrane technology has been shown to be useful in different areas; once we know the fundamental operations of membranes we can apply them to solve problems in industry. All membrane operations are simple and modular, and are attractive in process engineering. Engineers are familiar with their use and effectiveness. The strategy we use when applying membrane technology to environmental problems is to try to introduce their use right from the initial design phase.

Professor Drioli then outlined the basic properties of the most common membrane operation modes including the concept, driving force, species passed and species retained for the following processes: microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodyalisis, dyalisis, gas permeation, pervaporation, supported liquid membrane, membrane distillation, per-traction, and membrane reactor. Particular attention is devoted to the development of membrane operations for the rationalization ofindustrial productions.

Membrane technologies have shown their potentialities in molecular separations, clarifications, fractionations, concentrations etc., both in liquid phase, gas phase, and in suspensions. The significant variety of existing membrane operations is based on relatively simple, compact and largely clarified fundamental mechanisms, characterizing transport phenomenain the dense or microporous membrane phases and at the membrane solutions interphases.

All the operations are modular, easy in their scale-up and simple in their plant design. They are athermal (except for membrane distillation), don't require the additionof chemicals, are gentle and nondestructive, require no moving parts, work totally unattended, have low costs and operational flexibility and, when necessary, are portable.

Membrane operations cover practically all existing and requested unit operations used in process engineering. Their overall properties make membrane operation ideal for the design ofinnovative processes where they will carry on thevarious necessary functions, optimizing their positive synergic effects. Coupling ofmolecular separations with chemical reactions can be realized in a single unit efficiently, realizing ideal reaction surfaces where products can be continuously removed and continuously supplied at stoichiometric values.

New membrane operations as the membrane contractors and the combination ofmolecular membrane separations with chemical reactions in the catalytic membrane reactors, are contributing significantly to innovative design ofvarious processes characterized by interesting direct and indirect energy consumption. Professor Drioli outlined the energetic substitution coefficient which was defined as primary energy saving divided by electrical energy used, and the exergetic substitution coefficient which was expressed as the saving in useful thermal work divided by the increase of useful electrical energy work.

Interesting results have been achieved in different industrial sectors such as the leather, agrofood, pharmaceutical, and textile industries, There are approximately 3000 small leather and tanning companies in Italy. IRMERC is introducing membrane process into the most advanced of these. The outstanding issue is one of education. Professor Drioli then showed several illustrations of the use of a various membrane processes in the production of finished leather and tanning. These included a proposed process scheme for the treatment of waste water from a filter pressing process, and example of the use ofultrafiltration coupled with a bio-reactor for the treatment oftannery effluents, and a proposed scheme for the reuse of the exhausted chromium in tanning which combines the use ofnanofiltration and ultrafiltration.

A similar concept is being used in the desert to recover drinking water from sea water. Membrane distillation is introduced in addition to reverse osmosis to increase the recovery factor from 60% to 90%.

The same problems occur in the agrofood industry in Italy. Professor Drioli discussed the use ofintegrated membrane processes for the production ofconcentrated orange juice. This process included the use of cross flow microfiltration, ultrafiltration, reverse osmosis, and membrane distillation.

The concept remains the same throughout, concentration and reuse of resources which ensures the elimination ofenvironmental problems. Membrane technology is being used more widely today because the concept is simple and it can be applied to various problems.

Cleaner Production in the Czech Republic
(D. Sucharovova, Czech Ministry of the Environment and V. Dobes, Czech Cleaner Production Centre)

The Czech Republic is facing challenges ahead in the course oftransition. Czech enterprises are under the competitive pressure of a free market economy, while faced with increasingly tougher environmental regulations. Cleaner production (CP) is a win-win strategy to overcome these two seemingly conflicting challenges by promoting clean products and processes.

This presentation focused on the experience ofthe promotion of CP in the Czech Republic since 1992 and it consisted oftwo parts, In the first part Dr. Sucharovova gave a general introduction to the Cleaner Production Program in the Czech Republic which focused on national CP policies. She opened her discussion by stating that the Czech Republic with its neighboring countries of Hungary and Poland has become a member of NATO; therefore, the Czech delegation took part in this meeting as a member country for the first time.

Dr. Sucharovova informed attendees ofthe steps which the Czech Republic has taken to promote their Cleaner Production Program since the first NATO clean processes meeting. The Czech government approved the National program on eco-management and the audit scheme program, EMAS, in July, 1998. This program creates a legislative and administrative framework for EMAS within the country for our producers. Currently there are 23 companies certified according to IS0 1400 1 and 3 companies validated according to EMAS.

Presently, the neoCzech state environmental policy is being finalised. This policy is based on the preparation of an integrated pollution prevention strategy, which gives considerable importance to the collaboration and application of new software tools in environmental protection. For this reason we are preparing an integrated product orientated policy.

In light ofthis, Dr. Sucharovova informed attendees that the following two projects are being financed by the government within the framework ofthe “Science and Development” program:

Analysis ofnew tools for an integrated product orientated policy used by businesses with a focus on the utilisation of LCA.

Development ofan application methodology for the implementation of BAT in the Czech Republic.

The results ofthese studies are expected to be presented at the next meeting ofthe NATO pilot study.

Cleaner Production Centre

In the second part of the presentation, Mr. Vladimir Dobes gave more detailed information on capacity building programs (demonstration projects and training of local consultants and trainers) and on involving all stakeholders through a National Cleaner Production Centre (CPC). Mr. Dobes, director ofthe CPC, explained that the Centre is a non-governmental organization with close links to industry. It is comprised of a steering committee and a central office with branch offices which works closely withuniversities and industry.

Mr. Dobes then explained diagramatically that providing solutions to problems often means following a circuitous route which involves a full analysis ofthe causes ofthe problem, option generation, feasibility studies and finally solutions. The CPC has expanded its methodology to look closely at the percentage ofchemical inputs into a particular process actually end up in the product and the associated cost of pollution which arises from wasted input.

The CPC is using recent strategies and tools to solve environmental problems and create sustainable enterprise, and focuses on interactive training between academia and private enterprises.

Environmental management on enterprise level includes the use of management tools such as CP assessment, environmental auditing, and LCA; the use ofenvironmental systems such as EMAS, IS0 14,000, and total quality management; the use of strategies for eco-efficiency and cleaner production with an increasing degree of environmental protection such as end-of-pipe technologies, recycling, improving production processes, and ecodesign of products and services; and, finally implementing concepts such as Agenda 2 1 to reach the primary objective ofsustainable enterprise.

Mr. Dobes, informed attendees about the concrete results from several cleaner production projects implemented in the Czech Republic. The results of a survey of 52 companies engaged in CP projects within the Czech Republic indicate that up to 25% ofpollution reduction was obtained using good housekeeping activities. There were savings of approximately $30,000 per enterprise over those with no investment and total savings were approximately 1% of turnover. Savings on CP were 12 times higher than savings on treatment options.

To select the focus ofresearch there is an initial review and diagnosis which is very important. One of the main problems encountered in industry is the management system. An efficient management system is needed to ensure continuous environmental improvement of the system. There has been good progress in enhancing environmental management systemsin companies. An important aspect is to analyse where pollution is occurring in the plant. The CPC has used students to collect and process data on various industries to identify sources of pollution.

Mr. Dobes emphasized the difficulties involved in obtaining information on state of the art techniques for pollution prevention. He also emphasized the need for information on the evolution ofprograms to develop new techniques for good pollution prevention planning in the future. The CPC could use both of these. The old legislation asked only for end-of-pipe data, but new legislation calls for data on pollution at the end ofindustrial processes. The CPC will use this data for benchmarking, and this will allow us to improve our diagnosis.

Mr. Dobes stated that the CPC needs information exchange on Best Available Techniques for pollution prevention and on the direction to be taken by research. The Center also would appreciate some new sophisticated techniques to evaluate existing techniques used in industry.

The Danish Centre for Industrial Water Management
(Henrik Wenzel, Technical University of Denmark)

Dr. Wenzel's presentation consisted of a discussion ofthe objectives ofthe Danish Centre for Industrial Water Management (DCIWM), a look at the structure of the Centre and the partners involved, a review ofthe concept of water reuse, and an outline of two examples of this concept in the cotton dyeing industry and in an industrial laundry.

Dr. Wenzel outlined various partners involved in the Centre including five industries, three research and development institutions, and three universities within Denmark. The volume ofwork is around 50 man-years and the time frame for completing this work is between January, 1999, and January, 2003.

The objectives ofthe Centre are:

To develop concepts and technologies for reuse ofwater and waterborne energy and substances in industry.

To develop a method for choice of the concept and technology based on knowledge of the physical, chemical and biological properties of the water streams and on the water quality requirements ofthe processes.

To eliminate technological barriers to the use of essential water treatment techniques, especially membrane filtration.

To eliminate microbiological/hygienic barriers to water reuse.

To investigate and/or develop options for reuse/utilisation of concentrates from industrial waste waters.

To develop and implement solutions at the 5 partner companies; and, to disseminate experience and results.

The structure ofthe DCIWM consists of a steering committee, the Centre management, a project co-ordination group, and three main industrial drivers which are the food, textile and paper sectors. Industry is supported through research projects which examine the hygienic quality of recycled water, the scaling and fouling ofmembranes, and the utilisation of concentrates. The Centre supports the development of a generic method to look at water type as described in physical, chemical and biological parameters and to see how to use it.

Dr. Wenzel then outlined the concept of water recirculation and the strategy for this technology development. The water input to industrial processes has particular water quality requirements including temperature, pH, salt, bacteria, organic matter, colour, nitrogen, phosphorus, and heavy metals depending on whether the water will be used for dying, washing, rinsing, or mechanical processes. The water output from these processes must be upgraded using a variety oftreatment processes such as activated carbon, chemical precipitation, membrane filtration to ensure it meets input water quality requirements and can be reused. Using these treatment technologies ensures water is recirculated within a plant rather than discharged.

Dr. Wenzel showed three graphs outlining the use ofrinsing water for equipment from textile printing, for ion exchange installation, and for sand filtration ofgroundwater. The graphs illustrate that much ofthe rinsing time is unnecessary as the majority ofpolluting matter is eliminated up front in the rinsing process. Reducing rinsing time which is unnecessary for the elimination ofpollutants can reduce excess consumption ofwater.

The first example ofwork underway in the Centre was outlined by Dr. Wenzel. This consisted ofa review ofthe reactive dying of cotton in a batch process. This is a water based process which accounts for approximately 50% of all textile dyeing worldwide. Dr. Wenzel showed a graph which compared the percentage of specific contaminants in the effluent from the process in each rinse. In addition to determining that rinsing time could be reduced, the Centre examined four techniques for improving the quality ofthe rinsing water and ensuring water reclamation. These techniques, which included activated carbon adsorption, membrane filtration, chemical precipitation, and counter current evaporation, all worked but one had to be selected. Each ofthese technologies were compared based on their ability to improve the quality ofthe process water with their overall cost. On this basis, membrane technology was ultimately deemed the best for treating the rinsing water,

The following ongoing projects are currently being examined for use inindustrial laundries:

A model for the reuse ofwater, energy and substances based on water pinch techniques.

A simulation model for direct water reusein batch processes and full-scale experiments for calibration ofthe model.

The reuse ofwater, energy and substances in batch processes by membrane filtration.

The use of life cycle assessment of alternative concepts.

All ofthese are currently being evaluated. There are no results yet.

Utilization of the Waste Brines from the Sea-Salt Production
(Stefka Tepavitcharova, Bulgarian Academy of Sciences)

Technologies such as regeneration and recycling aimed at utilizationofwaste products are current activities ofthe Bulgarian scientists (chemists and ecologists) in the field of clean processes and products. One ofthese technologies deals withutilization ofwaste brines from sea-salt production.

The sea-salt production is based on sea-water evaporation, which results in concentration of a significant number of components. When the solution density reaches 1.225 - 1.235 g/cm^3, crystallization of pure NaCl occurs. After the NaCl removal, the highly concentrated waste brines are deposited back into the sea. These processes cause an osmotic shock to living organisms (ecosystems) in the sea.

The technology developed has 2 aspects: i) amethod allowing practically complete utilization ofthe major components (Na^+, Mg^{2+}, K^+, Cl- and SO_4^{2-}) present in the waste brine after sea-salt production and isolation of some inorganic salts; and ii) a way ofpreventing the living organisms from the harmful effect ofthe deposited waste brines.

This method comprises4 stages: (i) formation ofgypsum ($CaSO_4 \bullet 2H_2 0$) ; (ii) formation of$Mg(OH)_2$ and MgO, respectively; (iii) formation ofKC 1, NaCl and $CaCl_2$; (iv) conversionofgypsumwith aview to obtaining CACO,, and $Na_2SO_4 \bullet 10H_2O$.

Complete precipitation of SO_4^{2-} ions from the initial waste brine as $CaSO_4 \bullet 2H_2O$ (gypsum) is achieved using a $CaCl_2$ solution, A maximum conversion degree (98-l 00%) of $CaSO_4 \bullet 2H_2 0$ into $CaCO_3$, is reached using solid Na_2CO_3. The filtrate is allowed to evaporate and pure $Na_2SO_4 \bullet 1\ 0H_2O$ crystallizes.

After removing $CaSO_4 \bullet 2H_2O$, the brine filtrate is treated with $Ca(OH)_2$, to permit precipitation of all Mg^{2+} ions as $Mg(OH)_2 \bullet Mg(OH)_2$ is calcined at 920°C to MgO.

A definite part ofthe filtrate after the filtration of$Mg(OH)_2$ is returned to the first cycle again for complete desulphatization ofnew amounts ofinitial waste brine, while the remaining amount is gathered.

The solution consisting ofthe residue waste lyes ofall cycles is used for obtaining KC1 andNaCl. Afour-stage process has been proposed: (i) crystallization ofpure NaCl; (ii) co-crystallization of NaCl and KC 1; (iii) separation ofNaCl and KC 1; and (iv) crystallization of $CaCl_2$ aq or involving the solution in the first cycle again, in order to desulphatize new waste brine amounts.

Investigations have been performed with aview to establishing the state ofthe Black Sea coast ecosystems in two stations where waste brines from salt production are deposited in different ways. The presence of 119 species and forms are found in 8 systematic classes ofphytoplankton. There are differences in the effects established in the two stations: when waste brines are deposited on the bottom at some distance from the coast, the changes are minimum, while waste brines deposition in the coastal water leads to significant changes.

Deviations from the classical scheme of season dynamics ofthe phytoplankton as well as some peculiarities in the qualitative structure ofthe predominating phytoplankton species are established. From anecological point of view the dynamic change ofthe phytoplankton, which is a primary stage in the trophical chain ofthe sea, may lead to negative consequences with respect to the whole ecosystem. Regardless ofthelocal character ofthis effect, it may spread over a larger part of the Burgas aquatory due to the peculiarities ofthe currents in that part ofthe gulf

Management of Waste Activities in Bulgaria

Introduction

A project for a national program has been elaborated to promote the state policy in the field of the management of the activities for gathering, storage and utilization of the waste in Bulgaria in a midterm plan (1999 - 2002).

Analysis of the Status

The analysis of the existing state has been worked out based on the available information about the waste in the country, collected by the National Statistics Institute (NSI) and the Ministry of Environment and Waters (MEW). The accumulated practical experience during the last years and the results of particular research and investigations have been used as well.

As a result of the analysis three basic problems are formulated:

Increasing quantity of waste as a result of the prognosed growth of economy.

The necessity of huge social and private resources for effective management of waste.

Need of successful solving of current problems, simultaneously with the existing damages and old pollutions.

Cardinal Principles of the Program

Pure and healthy environment.

Rational use of the available raw material

Integrated management of the waste

Full responsibility of the pollutants on the base of "shared responsibility" and "pollutant fines."

Participation of the society.

Targets of the Program

Based on the analysis of the existing state, the specific conditions in Bulgaria and the main principles, the goals of the program are determinated in compliance with different components for the management of the waste.

1. Reduction and prevention of waste formation

Reduction of the waste quantities and following stabilization of these quantities

Reduction of contents of hazardous substances in the waste

2. Secondary use and recycling

Increasing the quantities of the recycled waste in the country by 20% till 2005 and by 30% till 20 10

Building of new capacities for waste recycling (including centers for old vehicle dismantling)

Widening of the system scope for deposit of packing materials for poly-use

Widening of the system for collecting of processed oils

Anew deposit system for batteries (accumulators) to be introduced

A new scheme of separated waste collecting to be introduced

3. Improving the organization for collecting and transport

A change of the investment policy of the municipalities entering the private capital activities for the management of the waste, concessioning of the activities of gathering and transport of the waste, and setting up a joint ventures for management of the waste are necessary.

4. Ecologicalwaste decontamination

Further continuing of the system of equipment and installations for decontamination of dangerous waste from the hospitals till 2010.

Adherence of the existing equipments and installations in compliance with the regulations in force till 2005; stopping the use ofequipment with emission ofhazardous substances with environmental impact and danger to the human health; close down and recultivation.

New equipments ofnational and regional importance, including new centers for treatment ofdangerous waste to be built in the period after 2002.

No importation of waste for decontamination in the territory of Bulgaria.

5. Reduction of the risk from old waste pollution

To embrace the old polluted sites in a system for prioritization and reporting of the activities for decontamination.

Close down of the uncontrolled depots and waste deposit areas.

Reduction of further risks from make-safe equipment.

6. Law regulation for management of waste

The adopted law for limitation ofhazardous impact of the waste on the environment and the appropriate regulations makes a lawful base for the transfer and implementation of the European Legislation in the field of the management of the waste.

7. Social Work

Provide access to information related to the management of the waste on a local, regional and national level.

Creative possibilities for the society to participate in the decision-making for the management of the waste.

Participation of the society in model projects for management of the waste.

8. Improving the system for monitoring, collecting information and control

Determine the objects, compose the national monitoring network and the index to be observed

Provide technical means for the system for monitoring.

Update the system for information; approve the control functions.

A new National Information Center for management of waste to be created after 2002.

Some Steps To Pollution Prevention

(Viorel Harceag, Environmental Research and Engineering Institute, Bucharest, Romania)

Research and Engineering Institute for Environment (I. C.I.M.) is known as a highly appreciated specialist institute with a comprehensive activity in the field of environmental component's ofmanagement and protection. The Institute is structured on specialised teams gathered in departments and laboratories with more than 20 - 30 years of experience in the field, and co-operation with nationally and internationally known specialists and university professors.

The I.C.I.M. is comprised of environmental components integrated monitoring, aquatic ecology and biodiversity, air quality, solid waste management, environmental radioactivity, urban engineering and ecology, water pollution sources and treatment solutions, and environmental legislation, economy and statistics.

On an economical contract base, I.C.I.M. performs research, studies, examinations and technical assistance in the specified domains. Deriving the advantages from the activity of about 250 higher-education graduates trained in a wide range ofspecialities (chemists, biologists, mathematicians, engineers, etc.), I.C.I.M., in an integrated concept, achieves specialist works, approaching both global and local problems, theoretical and practical aspects.

The Institute has complex material resources allowing a wide range of studies and research that imply physical and numerical modeling, pilot stations, complex technological experiments. It has also specific laboratory and field equipment for environmental components (air, water, soil, etc.) quality control:

The environmental components integrated monitoring include:

Water resources quality monitoring and management.
National background laboratory on water resources quality monitoring issues.
Water quality criteria and objectives.
National correspondent and focal point in connectionwith the International Register of Potentially Toxic Chemicals (IRPTC).
Environmental integrated monitoring systems in background and impact areas.
Data bank and syntheses.
Know-how for organizing data.

The aquatic ecology and biodiversity component includes:

Aquatic ecosystems monitoring in background and anthropic impact area.
Water pollution ecological assessment and control, aquatic and ambiental toxicological studies.
Establishing the quality state and tropic degree of the storage reservoirs and natural lakes (exploitation possibilities according to ecological criterion).
Evaluation ofanthropic impacts over biocenoses structure and functions in affected ecosystems.

The air quality component includes:

Air quality integrated monitoring systems in background and impact areas.
Air born pollutant emissions and sources inventory.
Data bank and syntheses at the level of the country (areas, regions, localities).
Know-how for organizing data analysis microlaboratories.

Impact studies.
Theoretical and experimental studies.

The fluid mechanics and pollutant dispersion component includes:

Pollutants dispersion into the atmosphere.
Noise pollution, shocks and vibrations.
Pollutants dispersion into rivers and storage reservoirs.
Hydraulic features ofhydrotechnical construction.
Harbour developments and coastal areas protection.

The solid waste management component includes:

Qualitative and quantitative features of municipal, industrial and agricultural sludge from water treatment.
Recoverable or toxic environmental compounds identification.
Waste management and data setting up.
Solutions for waste reinstatement in the natural economic circuit.
Waste disposal under environmental protection conditions.

The environmental radioactivity component includes:

Data banks.
External dose calculations.
Impact studies (nuclear/industrial objectives).
Know-how (networks/laboratories organizations, methodologies and methods for determining environmental radioactivity level).
Monitoring (technical - scientific assistance).
Air, water, soil, depositions, vegetation, foodstuffs.

The urban engineering and ecology component includes:

Drinking water supply for human settlements.
New technologies and materials for surface and groundwater, in view of their use for localities water supply.
Water supply of main or cooling circuits ofthermoelectric or nuclear power plants under energetic safety and environmental protection conditions.
Municipal solid wastes controlled treatment and disposal.

The water users quality assurance components are:

Water analyses regarding: physico-chemical, biological and bacteriological characteristics of water sources for water supply; water quality in distribution systems; and identification of types oforganic impurifiers through modem methods.
Water treatment technologies such as: treatability of water from different surface and groundwater sources; source pollution impact over water supplies; and special water treatment technologies.

Water pollution sources and treatment solutions include:

- Wastewater qualitative and quantitative characteristics determination.
- Treatment technologies and equipment development.
- Technical assistance for wastewater treatment plants management and operation.
- Training ofwastewater treatment plants personnel.
- Chemical products biodegradability determination.
- Recovery ofuseful substances from wastewater.
- Wastewater impact studies.
- Pollution prevention assessment and measures.

Environmental legislation, economy and statistics include:

- Research, system analyses, techniques and methods, methodologies and case studies. Strategies, plans and action programmes.
- Achievement and implementation of ecological reconstruction programmeswithintemational financial support.
- Technical assistance in the field of environmental economy and statistics.

For many years, all our actions in the wastewater treatment field were conducted using "end of pipe" approach. We have developed technologies of industrial and municipal wastewater treatment, facilities and equipment for wastewater treatment plants, after their collection from different pollution sources in industrial facilities.

One example is a static sieve for suspended solids removal from raw wastewater, used as pretreatment equipment, before mechanical treatment step. Developed as "end ofpipe" equipment, we haveused it also in some paper and pulp facilities to recover (in order to be reused) fibres of cellulose directly from wastewater next to pollution sources. It is one ofthefirst pollution prevention measures used in our country:

Other pollution prevention measures were transferred from "end ofpipe" technologies using membrane processes for dye recovery in the textile industry. We have also used membranes in metal processing for oil recovery. All these pollution prevention measures were established without systematic studies.

The concept oflife cycle assessment (LCA) is used to evaluate the environmental effects associated with any given activity from the initial gathering ofraw material from the earth until the point at which all residuals are returned to the earth. LCA is a technical tool to identify and evaluate opportunities to reduce the environmental effects associated with a specific product, production process, package, or activity. Implementation of opportunities pointed out in the third stage ofLCA can be made using pollution prevention techniques.

In the last years we have started LCA studies in different industrial fields, used as a first step to pollution prevention. One ofthese studies was conducted for the iron and steel industry - sintering plant, using US EPA methodology, presented below. It was presented in a poster section ofNATO workshop "Tools and Methods for Pollution Prevention," held in October 1998 in Prague, Czech Republic.

In this case study, the goal ofthe analysis was to identify those zones on the sinter manufacturing flow with relevant effects on the environment and to set the most efficient solutions to improve the system.

To establish the scope ofthe study, we shall identify what level ofdetail is required for the application ofthe results. So we have to indicate if

- the product analysed changed much over the past decades;
- the technology ofobtaining the product changed substantially;
-the method of sinter productionvaries from a sintering plant to other sintering plant.

We consider the system defined by the following operations: raw materials preparation, ore burdening, ore homogenizing, sintering and cooling of sinter, up to transport of the sinter to the blast furnace bunkers.

Table 1 outlines the environmental data sheet that includes raw materials and energy inputs and air pollutant outputs ofthe process fabrication for one ton of sinter. The contribution of each main processwas adjusted, using a contribution factor which represents the relative contribution ofthat process to the fabrication of one ton of sinter. Table 2 outlines the inventory table for 1 ton of sinter.

Table **1.** Environmental Data Sheet

Process: Sinter Fabrication
Plant: Sintering Plant
Data: May 1998

Inputs Fuel			**outputs**		
Electricity	44.00	kWh	Sinter	1,000.00	kg
Natural gas	2.37	Nm^3			
Coke gas	5.23	Nm^3	**Byproducts**		
Coke breeze	72.00	kg	Sinter returned	450.00	kg
Inputs Raw Materials			**Solid Waste**		
			Dust	120.00	kg
Iron ores	**970.00**	kg			
Fluxes	258.82	kg	**Emissions**		
Coarse dust waste	100.00	kg	Particulate	10.024	kg
Sinter returned	430.00	kg	CO	1.750	kg
			CO_2	155.220	kg
			NOx	1.004	kg
			SOx	1.150	kg
			VOC	0.450	kg

Table 2. Inventory Table for 1 Ton of Sinter

	Sintering (per ton)	Iron ore preparation (per 1670 kg homogenised)	Coke breeze obtaining (per kg)	Coke gas obtaining (per Nm^3)	Electricity production (per kW)	Total
Contribution factor	1	1	72	5.23	44	
Raw Material Resources' (kg)	1,670.0		1.11	3.2	0.21	**1,775.90**
Energy Resources (GJ)	2.133	0.0072	**0.01**	0.000785	0.01	3.30
Emissions to Air (kg)						
Particulate	10.024	27.00	0.0126	0.0084	0.00005	37.977
c o	12.750		0.0010	0.0007	0.00006	12.828
CO_2	155.22		0.099	0.0670	0.62500	**190.20**
NOx	1.004		0.0009	0.0005	0.00003	**1.07**
s o x	1.150		0.0050	0.0031	0.00024	**1.51**
c o v	0.450		0.0021	0.0014	0.00011	0.62
Waste Water (kg)						
COD			0.00014	**0.00009**		**0.01**
NH,+			0.00014	**0.00009**		**0.01**
Suspended solids			0.0020	0.00131		**0.12**
Solid Waste (kg)	-	-	0.028	0.019	0.000032	**2.12**

Inventory analysis results form the base of impact assessment. This stage of LCA consists of classification; all environmental "stressors" (resources used as inputs and emissions vented to the environment) are classified according to the kind of environmental problem to which they contribute, and characterization (including normalization) contributions to each environmental problem are quantified; and valuation-the environmental profile is converted into an environmental index. Table 3 outlines classification and characterization for 1 ton sinter fabrication.

This is particularly the case when two or more products have very different environmental profiles, or when it is required to relate a specific product to a standard. Having in view the goal of this case study, this stage is not discussed. The values of each impact parameter on the inventory table were multiplied by the values of equivalency factor correspondents. The results are shown in Table 3; note that one parameter may score under several

Table 3. Classification and Characterization for 1 Ton Sinter Fabrication

	R.M., kg	E.R., GJ	Emission to Air, kg						Waste Water kg		
			Panic.	CO,	CO	NOx	sox	voc	COD	NH,'	
Inventory analysis	1,775.2	3.30	37.975	190.2	12.8	1.07	1.51	0.62	0.01	0.01	
Equivalency factors											
GW (kg/kg)	-	-	-	1							
PO (kg/kg)	-	-	-					0.38	-		
HT (kg/kg)	-	-	4.75		0.01	0.78	1.2	-	-	0.02	
E (kg/kg)	-	-	3,500.0								
AD (-/kg)	1x1 0^{-12}	-	-								
ED (GJ)	-	1	-							-	
AP (kg/kg)	-	-	-			0.7	1.	-	-		
NP (kg/kg)	-	-	-			0.13			0.02	0.33	
Multiplied characterization results											**Total**
GW (kg/kg)				190.2							190.2
PO (kg/kg)								0.24			0.24
HT (kg/kg)			180.4		0.13	0.83	1.81			2.10^{-4}	183.17
E (kg/kg)			139,913								139,913.0
AD (-/kg)	1.8 10^{-9}										1.8 10^{-9}
ED (GJ)		3.30									3.30
AP (kg/kg)						0.75	1.51				2.26
NP (kg/kg)						0.14			2-l0^{-5}	33.1 0^{-4}	0.14

environmental problems simultaneously. The final result consists of a score for each environmental problem analysed, which can give an image of possible impact produced by sinter fabrication.

Classification and characterization followed by normalization for 1 ton sinter fabrication is presented in Table 4.

The results of the inventory analysis and impact assessment conduced to study the effects on the environment produced by processes components of sinter fabrication system (iron ores preparation, coke production, electricity production and sintering), in the frame ofimprovement analysis.

Table 4. Classification, Characterization, and Normalization for 1 Ton Sinter Fabrication

Environmental Problems	Score	Unit	Normalized Score (a.10^{-12})
Global warming	190.20	kg	5.05
Phototchemical oxidant creation	0.24	kg	64.20
Human toxicity	183.17	kg	318.00
Terrestrial ecotoxicity	132,930.00	kg	114.59
Abiotic depletion	1.8×10^{-9}	a^{-1}	1,698.00
Energy depletion	3.30	GJ	14.04
Acidification potential	2.26	kg	7.90
Nitrification potential	0.14	kg	1.87

The finding of this interpretation may take the form of conclusions and recommendations to decision-makers, grouped in: actions to reduce electricity and actions to minimize pollutant emissions.

For these it is necessary to take the following measures:

Efficiency increasing as a result of sintering installation improvement by:
Advanced control of burning front—
best distribution of coke granulation in sintering bed;
best gases permeability through sintering bed as a result of good preparation of raw materials;
reduction of false air exhausting;
modernization of ignition system with the purpose of fast start burning at high temperatures (lead to a decreasing of coke-oven gas consumption).

Increasing of heat use efficiency—
reusing of gas heat for preheating of combustion air (this leads to an increasing of flame temperature) and raw materials;
reusing the heat of sinter cooling air for preheating of combustion air and raw material - when cooling air has low temperature - or for steam production - when cooling air has high temperature;
reduction of heat losses as a result of decreasing of sinter returned material;
recirculation of sintering gases.

Reduction of dust emissions can be done first of all by best handling operations of raw materials. So, reusing of fine blast furnace dust and fine sintering dust must be forbidden without a previous pelletising. Taking in consideration the big quantity of dust, in preparation shops, a hood must be installed, or the exhaust system resized.
Because the dust is in a great quantity in the zones where air, respective the cool air has high temperature, an efficient method to reduce the level of dust emissions is recovery of heat eliminated with cooling air.

Reduction of SO, emissions to stack can be realized by using raw materials and fuels with low level of sulphur (when that is possible).

Reduction of NO_x emissions in combustion gases is possible by diminishing the volume of false air exhausted and by improving the burning.

Using LCA results and pollution prevention measures established, industrial managers have the opportunity to choose for industrial modernization such technologies so as to achieve maximum effect at the lowest cost. They are only low and non-waste technologies focused on source reduction or recycling activities, either requiring greater capital investment, or saving money in their operation, through more efficient use ofvaluable resources and reduced waste treatment and disposal costs, Installing more efficient process equipment or modifying existing equipment to take advantage ofbetter production techniques may reduce waste generation. New or updated equipment can use process materials more efficiently, producing less waste.

Clean Processes and Products in the Slovak Republic

(Lubomir Kusnir, Ministry of Defence of the Slovak Republic, Department of the Environment)

The main branches of industry in the Slovak Republic after process oftransformationand industrial relations are the metallurgical industry, chemical industry, machinery industry and food industry.

There has been created considerable portion of industry with lower level of workup and with high raw material, energy and transport pretension as the development showed until today. In the structure ofproducts are mainly sub-supply, half products and simple consumer products. There is considerable lag behind in finish of production. The industry of the Slovak Republic is not able to provide energetic investment from own sources.

The most significant volume ofinvestment has been realized in these industry sectors: petroleum, chemical, plastics, wood, paper, food and energy production.

Concerning cleaner productionin industry, the following tools are being used for its promotion.

Environmental evaluation and eco-labelling of products

The Government Resolution No. 97/1 996 approved creating a "national programme of environmental evaluation and labeling of products in the Slovak Republic." The national programme was declared after the organizational and institutional securing by Minister of Environment in April 1997. The document has been published along with first guidelines of this programme. These guidelines were published for individual product categories. The rights to use the eco-label for these products has been awarded by Minister of Environment, Eco-labelling of products is going to obtain an advantage in increased competition ability for producers. On the other hand it gives the consumers state guaranteed information about the minimalization negative impacts of products and production on environment and it encourages consumers to buy and use these products.

Environmental management systems

The basic standards for installation of environmental management systems in enterprises and organization is set of standards IS0 14000 which we called "environmental management," published by Commission of International Organisation for Standardization ISO/TC 207. The Slovak Institute of Technical Normalization created Technical Normalization Commission No. 72, called Environmental Management in 1996 whichmain task was solving these norms in the system of Slovak technical norms. There were published four of these norms in the Slovak Republic considering this work:

STN EN IS0 14 00 1	Environmental management systems - specifications with instructions on its use
STN IS0 14 004	Environmental management systems - general instructions on the principles, systems and supporting techniques.
STN EN IS0 14 0 10	Instructions on environmental audit (general principles)
STN EN IS0 14 0 11	Instructions on environmental audit (procedures of audit, audit of environmental management systems)

The norm IS0 14 00 1 is the certification norm for installation and certification of environmental management systems. Efficiency ofinstallation systems proves certification audit. On this basis certification authority gives the certificate to the organization. In January 1997 was created Technical Committee for Accreditation of the certification authorities which certified systems of environmental managers (TVA-COE). These committee-elaborated methodical guidelines for accreditation according to EN 45 0 12, ISO/IEC Guide 6 1 and EAC Guide 5 and in sense ofinternational criteria EARA, has been prepared for accreditation and certification process by group of experts forjudgment and environmental audit.

Government Support

The Government of the Slovak Republic declared in its programme creating conditions for process of restructuralization of industry to allow approach its qualitative parameters for global world market. The most appropriate forms of state participation are government development programmes in framework industrial policy.

The Government of the Slovak Republic approved "The Actualization of Industrial Policy" in 1997. The document includes system of the state participation on the promotion competition ability of the Slovak industry according to principles European Union, World Trade Organisation and OECD. There are some proposals for the future procedure in the process ofrestructuralization of the Slovak industry from 1998 to 2005. The part of this document includes :

- Programme oftechnical and innovation development
- Programme ofincreasing level of quality and industry design
- Programme promotion of environmental management and audit in industry
- Programme of promotion utilization of secondary raw material
- Programme of development andutilization ofbiotechnology

Considering the above mentioned programmes state technology policy have also to provide:

- Tasks of the strategic innovation programme
- Training exercises and courses as a part of innovation programmes
- Network ofinnovation services for business sphere
- Creating know- how bank

Coordination and securing scientific and technical tasks are carried out by technical centres and concern associations ofcentres and development working place in private and state sector.

International cooperation

The Slovak Republic participates in a number of international programmes for scientific, research and technological development. For example, we were taking the participation at the Fifth Framework Programme of the European Community for research, technological development and demonstration activities (1998 to 2002), and we also use some support services as CORDIS (Community Research and Development lnformation Service) which is an information service of European Commission about research in European Union, TII (Technology Innovation Information) supported by European Commission with aim transfer oftechnologies and promotion of innovation, etc.

Finally, Mr. Kusnir mentioned some examples of ongoing research projects concerning clean production:

Institute of Material Research of the Slovak Academy of Science

- Secondary recystallization and microstructure design of electrical steels
- Influence ofmicrostucture on failure micromechanism and limiting state of steels and sintered materials

- Relationship between microstructure and mechanical properties of nanocrystalline materials on Cu- base, etc.

Institute of Polymers of the Slovak Academy of Science

- Preparation and modification of polymers, polymer blends and composites oriented to development of products with specific properties
- Search for new procedures improvement ofutility properties in assortment ofpolymeric materials
- Research on photooxidative, thermo and combustion reactions

Institute of Chemistry of the Slovak Academy of Science

The scientific activities focused mainly on chemistry and biochemistry ofcabohydrates with emphasis on research directions as:

isolation and structural analysis of biotechnologically active polysaccharides and their chemical modification, synthesis and structure of mono- and oligosaccharides, gene engineering ofnutritive and regulations proteins, bioengineering of polysaccharides, synthesis ofbiologically active carbohydrates combined with nitrogen heterocyclic compounds, etc.

Institute of Electrical Engineering of the Slovak Academy of Science

- The projects are mainly oriented in the field ofsemiconductors and superconductors: high-temperature superconductivity, semiconductor heterostructures, etc.

However, there are a number of other research and development activities.

Some examples of the application of clean technologies in the major manufacturers in the Slovak Republic:

- Technology for treatment heavy oil fractions which eliminates the high sulphur content of products; used in the largest petrochemical company
- Technology for coatings manufacture which minimize use of chromates in pigments and organic solvents in its products (powder coatings, high solids coatings)
- Technology which minimizes air pollution - sulphur dioxide (SO_2) and nitrogen oxide (NO_x) emissions solid fuels firing in fluidized - bed; used for energy production
- Technology on propylene chlorohydrin dehydrochlorination and modification of propylene glycols rectification ; used in chemical industry
- Technology for production ofbleached pulp grades (during bleaching process is used only a little amount of gas chlorine) - oxygen bleaching process; used in the largest sulphate pulp mill in the Slovak Republic.

Danish Product-Oriented Measures in the Textile Industry
(Henrik Wenzel, Technical University of Denmark)

Dr. Henrik Wenzel's presentation gave an overview of the Danish product-oriented environmental initiative and focused on measures undertaken in the textile industry which include the textile product panel, the textile LCA database, and guidelines for the public purchase of textile products and laundry services.

The Danish product-oriented environmental initiative was launched by the Danish Environmental Protection Agency in late 1996, in the shape of a draft proposal for debate between stakeholders. Since then, all essential stakeholders have given their comments and criticism to the draft. In general, the attitude towards the proposal is very positive, and both industry, authorities, consumer associations and other interested parties support the intention to increase product-oriented environmental measures.

In 1998, a five-year subsidy scheme was passed by the Danish Parliament, under the title Cleaner Products Program. This scheme is a prolongation of the past year's Cleaner Production Programmes, and the new focus on products has, thus, been carried through.

Dr. Wenzel began his discussion by outlining the life cycle of blue jeans including indigo production in Mexico, cotton growing in India, weaving and dyeing in Taiwan, sewing and washing dyestuff off again in Lesotho (stonewashing), and ultimately product use in Denmark. This begs the question why such a widely distributed production process is employed? The answer is this form of production is most cost effective.

Dr. Wenzel outlined measures which could help to improve the environment in Lesotho where rivers have been polluted from the discharges from stonewashing activities. These include substituting stones by enzymes in the stonewash, dying the jeans a light blue from the beginning, encouraging the public to wear dark blue jeans.

The product-oriented environmental initiative addresses both the technical sphere (the products and systems), the economic sphere (the market) and the social sphere (the stakeholders) and acknowledges the fact, that all spheres must be developed if the initiative is to succeed substantially. All stakeholders will have to recognize their responsibilities, and information, guidelines, methods and tools must be supplied in order to support the supply and demand ends of environmentally friendlier products, Moreover, market conditions must be ensured that allow environmentally friendlier products to be economically favorable to a company.

Elements of the Danish product-oriented environmental initiative include developing general market conditions by providing information and educating stakeholders, encouraging dialogue between stakeholders, using green taxes, fees, charges, standards and norms, and the possibility of using legislation, To satisfy the demand element there must be consumer information such as eco-labelling, EMS tools for industry and public institutions, public purchase legislation, and public purchase guidelines. In regard to supply, there must be a supply ofiiormation and the education of decision makers in industry, using EMS and LCA tools and databases for industry, and cleaner production and product development, Pilot product areas include textile products and electronics and freight transport.

The cleaner products subsidy scheme has been put in place to catalyse these activities. This scheme consists of the development programme which is comprised of four parts including: the development ofknowledge, methods and tools; the development ofcleaner products; the development of the market; and waste reuse and recovery. The scheme also consists in the use of standard subsidies to include capacity building in industry and environmental labeling to support industry.

Green public purchase incorporates a Danish set of rules, agreements and guidelines which includes: legislation on environmental considerations governing purchasing by state institutions; agreement on environmental considerations governing purchasing by county and municipal institutions; a general manual on green purchase and how to make a purchase policy; and product-specific purchasing guidelines.

The available guidelines in 1999 include:

Productsfor handicappedpeople: wheelchairs, beds & mattresses,
Office articles: writing- and copy machine paper, envelopes (draft), other office articles (draft)
Office equipment: copy machines, PC's, printers, fax machines, other office machines,
Canteen equipment: stoves, refrigerators, freezers
Furniture: tables, book shelves, file cabinets, upholstery furniture, office chairs (draft), school chairs (draft)
Hygiene-products: diapers, kitchen- and toilet paper
Transportation: Cars, tires, transport services, carriage way marking
Printedmatter: Offset print, copying services
Buildings: Paint, varnish, varnish services
Miscellaneous: district heating pipes

The initiative is managed by the Danish EPA. The Cleaner Products Council comprises stakeholders from the different product life cycle stages and advises the Danish EPA on strategies for the product-oriented initiative in general while defining a yearly priority framework for the subsidy scheme. Pilot product panels comprise representatives from the most essential stakeholder categories. These panels suggest goals, establish action plans, and suggests priorities for subsidies to the Cleaner Products Council.

Textile products has been appointed as one ofthree pilot product categories (together with electronics and freight transport) within which the initiative is to be tested and developed. A panel of stakeholders has been established with the task to suggest goals and action plans for the textile industry. The situation for the textile industry is advantageous. A number of cleaner productionoptions have been developed, eco-labelling criteria have been established or are on the way, and guidelines for "green" public purchase are under elaboration as is an LCA database. The textile industry is thus well suited for testing the initiative.

The textile product panel consists ofseveral stakeholders involved in design several manufacturers involved in supply, several consumer associations and retailers involved in demand, and the Danish EPA and consultants involved in marketing. All essential stakeholders in all stages in the life oftextile products are included.

At present the textile LCA database covers the life cycle of 8 product categories. The most essential processes are covered in these 8 categories. The objective ofthe LCA database is to cover the most essential unit processes relevant to the textile industry. Tables 1, 2, and 3 outline the information available in the LCA database.

Guidelines for the public purchase oftextile products and laundry services include white coats, common workwear, rough workwear, working gloves, bed linen, curtains, special clothing, and laundry services. Draft recommendations for guidelines for the public purchase ofwhite coats cover the following general recommendations including: looking for eco-labels such as the Nordic Swan and the EU flower; looking for organic cotton; looking for long product life and high quality (e.g. the Danish quality label "varefakta"); looked for an EMS at supplier, e.g. IS0 14001 or EMAS; and looking for suppliers with waste water treatment in wet processing. The draft recommendations also include life cycle orientated issues regarding using materials that have the lowest possible use ofpesticides and defoliants in cotton growing; avoiding hazardous substances including carcinogenic and allergenic substances in manufacturing (e.g. chlorine-containing bleaching agents, certain carcinogenic azo-dyes, heavy metal based dyes, formaldehyde, solvent-based carriers); looking for the EcoTex label to avoid allergenic and other hazardous substances in the product, and looking for suppliers that can take back and reuse/recover worn out products.

In summary, Dr. Wenzel explained that the stakeholdersin the textile industry are positive and have started a constructive dialogue. A product panel has been formed to outline the product oriented environmental strategy in the textile industry and establish an action plan. Public purchase guidelines are being elaborated for 7 product categories and laundry services, and finally an LCA database is currently being improved upon.

Table 1. The Textile LCA Database - Product Category and Fibre Type

Product Category	Fibre Type
A dyed knitwear blouse	Viscose/nylon/elasthan
A dyed knitwear T-shirt	Conventional cotton/organic cotton
A woven workwear jacket	Cotton/polyester
A dyed velour knitwear dress	Cotton/polyester
A woven jogging suit	Nylon microfibre
A pigment printed, woven table cloth	Cotton
A reactive printed, woven bed linen	Cotton
A dyed carpet	Polypropylene

Table 2. The Textile LCA Database - Objectives for the Materials and Manufacture Stages

Materials	
Cotton	Conventional, organic
Wool	Conventional, organic
Viscose	Stack-fibre, filaments
Polyester	Stack-fibre, smooth filaments, textured filaments
Acrylic	Stack-fibre, smooth filaments, textured filaments
Polyamide Nylon	Stack-fibre, smooth filaments, textured filaments
Standard components	Buttons, zippers, other
Manufacture	
Yarn production	Single yarns, twisted yarns, other
Knitting	Round, flat
Weaving	Sizing, Weaving
Pre treatment	Knitwear, woven, yarns
Dyeing	Cotton, wool, viscose, polyester, acrylic, polyamide, cotton/polyester
Printing	Reactive, vat, dispersion, water-based pigments, solvent-based pigments
Post treatment	Mechanical, chemical (softening, bio-polishing, stone-wash, moth proofing

Table 3. The Textile LCA Database - Objectives for the Use and Disposal Stages

Use	
Cleanina	Perchloro-ethylene, white spirit, CFC11, CFC13, other solvents
Washing	Household, industrial
Drying,	Household, industrial
Ironing	Household, industrial
Rolling	Household, industrial
Pressing	Household, industrial
Disposal	
Incineration	All fibre types
Depositing	All fibre types
Reuse	Select products
Composting	All fibre types
Recovery	All fibre types

Project: Tools for Pollution Prevention
(Subhas Sikdar, US. Environmental Protection Agency)

As the concerns for reducing cost and environmental impacts stimulate the growth of environmentally preferable products and processes, there will be need for appropriate scientific tools that enable the assessing, measuring, comparing and predicting ofenvironmental impacts and designing ofnewer systems. It is very important that these tools are publicly available for the benefit of small- and medium-sized companies and to all relevant enterprises around theworld. Transparency ofthe scientific and engineering principles behind these tools creates an easy technology transfer environment and encourages cooperative work among experts from different countries for improving these tools and creating more versatile ones. Looked at from the viewpoint ofR&D capacity building, these tools are potentially more important than the very designs ofcleaner technologies.

The tools can be classified two ways: analytical (or software) tools, and technology (or hardware) tools. Analytical tools areusually algorithms and models that perform certain desirable tasks. For instance, they can assist in assessing the environmental impacts of a product or process, or they can design cleaner systems, or compare alternatives. The iterative power ofthese tools provides for rapid analyses of alarge number ofsystems and address the so called "what if' questions. Examples ofthese tools are life cycle assessment, impact assessment, process integration and design, and material design. The second type oftools canbe described as technology tools. These are formulaic knowledge gained from experimental research. Examples are separation technologies, green syntheses of classes ofuseful compounds, and cleaner processing techniques. Dr. Sikdar focused on analytical tools only in this presentation.

There are a host of analytical tools being developed at variousinstitutions in theUnited States. The Office ofPollution Prevention (OPPT) ofthe US EPA has been instrumental in developing a number of assessment tools for pollution prevention. Companies, large and small, use these tools to evaluate how their products and processes fare with respect to specific environmental regulations. Some ofthese tools provide guidance on how environmental impacts can be reduced or eliminated. At the National Risk Management Research Laboratory in Cincinnati, researchers are engaged in developing tools that lead to better process and product designs. Four ofthese tools with their status are listed below.

Pollution Prevention Progress (P2P)

P2P is a measurement methodology for pollution prevention (P2) progress. It is auser-friendly, computer-based tool for assessing pollution prevented (or sometimes increased) as a result ofproduct redesign, reformulation, or replacement. This compares before and after snapshots and produces a variety of reports which describe P2 accomplished with respect to the media affected (water, soil/groundwater, air), categories of pollution impacted (human health, environmental use impairment, disposal capacity), and life cycle stages.

TheP2P tool provides classification information regarding22 specific classes ofP2 including toxic organics, toxic inorganics, carcinogens/teratogens/mutagens, fine fibres, heavy metals, radioactives, pathogens, acid rain precursors, aquatic life toxicants, global warmers, BOD, COD, nutrients, dissolved solids, corrosives, ozone depleters, particulates, smog formers, suspended solids, odorants, solid wastes, and hazardous wastes. P2P also takes into account energy-related pollution associated with any P2 action.

Originally the Mark I version was released in February 1995, and was revised and released as the Mark II version in July, 1997. P2P, Mark II includes the following improvements over Mark I: a database of almost 3,000 pollutants, the ability to search by CAS No. and synonym, the ability to deal with incompletely classified pollutants, and the ability to report potential regulatory impacts. This version is availablevia fax/email requests c/o Henrietta Hicks at 5 13/569-7111 (fax) or hicks.henrietta@epamail.epa.gov.

Development ofP2P, Mark III is underway and will include the following improvements over Mark II: a Windows-based program; the incorporation ofimproved human health and ecotoxicity classification approaches, and restructuring ofimpact categories to improve comprehensiveness; and consistency with other SAB tools.

Waste Reduction Algorithm (WAR)

The WAR algorithm allows a design engineer to identify cleaner process design options The algorithm investigates a number of potential environmental impacts around a well-defined process and characterizes it with a pollution index. A commercial simulator is needed to carry out the rigorous calculations. Emission and discharge information is required to use WAR. WAR will be available shortly from a commercial simulation company.

Dr. Sikdar outlined the production ofmethyl ethyl ketone (MEK) from SBA which is the base process to illustrate the use ofWAR. The impact categories evaluated using WAR include the ozone depletion potential, global warming potential, smog formation potential, acidification potential, human toxicity by ingestion potential, human toxicity by inhalation/dermal exposure potential, aquatic toxicity potential, and terrestrial toxicity potential ofMEK. The impact generation and output indexes for the production ofMEK interms ofthe impact per kilogram ofproduct were illustrated in graphic form. The WAR algorithm can be used to create a process flow diagram, calculate the mass and energy balances using a commercial chemical process simulator, determine the PEI indexes for the design, and use thePEI indexes to decide upon appropriate alterations in the process flow diagram. Dr. Sikdar then showed a modified flow diagram ofthe production ofMEK from SBA using amodified process based onthe output from WAR.

Program for Assisting the Replacement of Industrial Solvents (PARIS)

Part of a material design program, PARIS is a solvent design tool, i.e. it provides benign alternates for undesirable uni-component or multi-component solvents. The main part of the product is an algorithm that creates a “virtual solvent” in the computer by matching certain core and additional properties ofthe current solvent. PARIS is currently in the middle of a CRADA(cooperative research and development agreement) with a private sector company for release to the public in about six months.

Paris II is a solvent design software where a problem is specified (e.g. compound name, mixture composition, working condition, etc.) and a weight assigned to each environmental category. Target properties and environmental indices are calculated for the current formulation and these calculated values are used to specify target values. A tolerance percentage is then assigned to each property. The program then searches for a single chemical replacement. Ifno single compound is found, candidates are selected one at a time for a potential binary mixture. The binary mixture is studied for all composition ranges and if any specific formulation meets the requirements, the result is shown. Ifno formulations meet the requirements, the mixture is changed, components are added, and the process repeated.

Dr. Sikdar outlined a case study on the use ofParis II to search for a chemical replacement for MEK which had high weights assigned to several environmental indices. Lower environmental index values are desirable for the replacement. A replacement formulation found by PARIS II was 90% ethyl acetate and 10% ethanol. Practical problems with respect to pollution prevention can be solved through solvent substitution; however, problems need to be defined clearly and consistently. Efficient search/design engines such as PARIS which will point to promising alternatives suitable for further analysis, can be easily applied to solve these problems.

Tool for the Reduction and Assessment of Chemical Impacts (TRACI)

TRACI is adecision support tool in early development. It considers seven of the important impacts of the products we use. These are stratospheric ozone impacts, global warming, acid deposition, eutrophication, tropospheric ozone impacts, human toxicity, and environmental toxicity. TRACI is a framework which allows combining the individual chemical impacts of a chosen product in a rational manner so that an appropriate decision can be made about its manufacture and use.

Through subsequent years of this NATO CCMS pilot program the current development of these and other tools being developed will be presented and discussed.

Water Conservation and Recycling in Semiconductor Industry: Control of Organic Contamination and Biofouling in UPW Systems
(Farhang Shadman, University of Arizona and Mike Larkin, Queen's University)

Dr. Farhang Shadman began his presentation by introducing the key partners involved in this collaborative research effort. They include the Research Center for Environmentally Benign Semiconductor Manufacturing (CEBSM) at the University of Arizona; the Queen's University Environmental Science and Technology Research Centre (QUESTOR) at Queen's University, Belfast; and the Center for Microcontamination Control (CMC) at the University of Arizona. In addition, other project participants include the Center for Biosurfaces (CB) at the State University of New York and the Hazardous Substance Management Research Center (HSMRC) at the New Jersey Institute of Technology.

Dr. Shadman emphasized how exciting it is to have a multi-disciplinary, multi-centred international scientific collaborative effort underway and then proceeded to outline his organization's role in the project.

The manufacture of a microchip involves a layer-by-layer etching process. After each etching the chip must be washed thoroughly with several rinses to remove all molecular contaminants. Consequently, the very large usage of water in modern IC fabrication plants has become a major environmental issue and an obstacle against sustainable growth in the semiconductor industry. Major developments are needed towards use reduction as well as towards reuse and recycling of water.

One of the key problems against the implementation of recycle and conservation measures is the risk of accumulation of recalcitrant organic contaminants and consequently the risk of biofouling. Dr. Shadman stressed the need for concern regarding contamination by particles and bacteria in recycled water in addition to ionic contaminants. The purity requirements for this water are outlined in Table 1, some of which are lower than the

Table 1. Guidelines for Water Purity

Specified Property	Critical Device Dimension		
	0.8 micron	0.5 micron	0.3 micron
Resistivity @ 25°C (MΩ-cm)	18.2	18.2	18.2
Total oxidizable carbon, TOC (ppb)	10	5	1
Particles of this size or larger (pm)	0.08	0.05	0.03
Maximum cumulative count (#/lit)	500	500	500
Bacteria, total count (#/lit)	50	10	1
Bacteria, live (CFU/lit)	10	1	0
Silica, reactive (ppb)	0.5	0.1	0.05
Silica, total (ppb)	1.5	0.3	0.15
Dissolved oxygen (ppb)	100	50	25
Metals, alkali (ppt)	15	10	5
Metals, transition (ppt)	30	20	IO
Metals, total (ppt)	750	350	150
Anions, total (ppt)	375	175	75
Residue, total (ppb)	100	50	25

measurement techniques currently available. Another problem involves removing organic particles in such a way that they do not shatter into smaller pieces. Most techniques to remove organics for recycling, including membrane processes, adsorption processes or oxidation/reaction processes, are inadequate at very low tolerancesin addition to being major energy users; consequently, the technology needed here is different from that which isused for other water and wastewater purification situations.

This proposed study aims to identify the organic impurities that are among the recalcitrant compounds in the recycle systems and to develop unique low-energy treatment processes which would remove these compounds from the system. The test bed used for this study will comprise two UPW systems at the University of Arizona. This is a $2.5 million facility which is unique. It involves a number of steps including primary purification, secondary purification, and then constant recirculation around the polishing loop to ensure the purified water does not become stagnant.

Two processes are being developed which integrate reaction with separation: oxidation combined with degasification or oxidation combined with filtration. The oxidation methods of choice are UV 185, UV 254 with photo-catalyst and combined UV and ozone.

Dr. Shaman discussed each ofthese examples. One ofthe techniques being examined for bio-contamination control is the use of catalytically active filters or active membranes. As presently used, an ordinary filter very easily becomes a breeding ground for bacteria because it acts as a major point ofbiofilm formation and biological growth. The answer to this is a self-cleaning filter. The idea is to put photo catalytically active sites on the surface of a filter and constantly irradiate it with UV light; so as organic mass accumulates on the surface, the same site that removes it becomes a catalytic site for oxidising it, essentially becoming a self-regenerating filter. This idea has been patented and is currently being commercially developed.

The other way to achieve this is to put the same catalytic sites in membranes. Organic compounds that come into contact with the catalytic site are broken into smaller molecules which can easily cross the membrane and be removed by purging. In one geometry you are combining filtration with oxidation, and in the other, membrane degasification with oxidation. These will become very efficient methods for removing organic contaminants like bacteria.

Finally, another example of a technique which Dr. Shadman's group is looking at for biological control is novel oxidation methods. One such method is combined oxidation processes. The two oxidation processes currently employed include the use of UV light and ozonation. Each has a certain efficiency for removing organics. If the two are combined there is atremendous synergistic effect which is far more than the additive effect of the two. As a result of UV action on ozone, a high concentration of radicals is generated which act as a type of shock treatment for organic compounds and as a result much higher removal efficiencies are obtained.

The development ofthese techniques has recently commenced and more detailed resultswill be presented next year.

The Microbiological Component

The biofouling characterization and prevention component of this project involves a joint effort between researchers in the University of Arizona and Queen's University.

Dr. Mike Larkin from the Microbiology Laboratory at the QUESTOR Centre in Queen's University, outlined his group's involvement in this research project, He began by introducing the large team ofresearchers who work in the microbiology laboratory in the following areas: molecular biology/genetics, biochemistry of biodegradation and biotransformations, soil bacteria - rhodococcus genetic systems and regulation, extremophiles (salinity/pH), naphthalene dioxygenase evolution and mechanism, alkane dehalogenases, bioremediation (C 12:C 13 ratios), surfactant effects, sludge bulking and *Microthrix* detection. Experience and facilities available within the laboratory facilitate the following activities: PCR sequencing; cloning and automated sequencing; hybridisation/ribo-probes/(immunoprobes); chemical analysis including HPLC/GCMS/NMR etc.; FPLC protein purification; and fermentation.

The overall aims of the project are to improve the quality of water in UPW systems; to determine the relevance of these systems to the Northern Ireland electronics and pharmaceutical industries; to try to enable UPW recycling to be done; to learn more about microbial contaminants and their growth in order to detect and control them; and to develop and test an on-line monitor.

The contribution of Dr. Larkin's group to the research of the microbiology of the system includes: evaluating chemical composition (CEBSM); isolating bacteria (CMC) both anaerobic and aerobic species, and using growth substrates, ID, 16s 23s or degradative gene probes to look at their growth physiology in general; performing non-culturable detection; and looking at the key indicators of contamination.

The group's objectives include amassing a range of techniques which will validate microbe removal, the validation of the micro-biocontamination monitor (CB), the validation of an advanced oxidation process (CEBSM) and membrane degasification (HSMRC), and looking at the inter-dependence of the projects as a key factor.

The project started in January, 1999, and researchers from QUESTOR have already spent time in Arizona working on the project. To date, approximately twelve microbiological strains have been characterized and work is continuing at a rapid pace.

Conducting Research and Development Aimed at Developing Cleaner Production Technologies to Assist Textile Industry to Manufacture in Compliance with International Standards

(Nilgun Kiran[1], Zekiye Ayhan[2], and Akin Geveci[3])

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Abstract

The textile, leather and clothing industry is one ofthe most important industrial sectors in Turkey. In 1997, 20% ofthe industrial establishment were operating in the textile sector, which employed 30% ofindustrial workers. The textile sector has steadily increased its weight in the Turkish industry primarily due to its considerably high export potential. At present, the textile industry accounts for about 35% ofthe overall Turkish export.

The cleaner production (CP) programme for the textile industry in Turkey has to comprise a set of organisational, administrative and planning activities that aim at enhancing the CP approach throughout the production oftextiles and the management ofthe enterprise. Recently introduced regulations impose several limitations on the overall production chain ofthe textile industry within the frame ofthe cleaner technology methods. Elimination and reduction ofthe emissions and wastes in the textile sector have to include a thorough study ofthe water and energy utilisation infrastructure.

With the comprehensive set of cleaner production options, the feasibility phase of CP is carried out. The options which are concluded to be feasible and worth implementing are only recommendations for the textile company that is investigated during this project. During the investigation ofthe costs associated with raw material and water and energy in and outflows at the feasibility study, the commitment of the enterprise is of utmost importance. Since without their mutual and financial support there will be no real actions and no real results. On the top of everything, no firm will implement any water and/or energy and/or raw material conservation measure ifthe modification has an unacceptable impact on the finished product.

Introduction

The way to promote the CP concept in Turkey has been to apply CP methodology in one ofthe biggest sectors. During the past decade Turkish textile and apparel industry grew rapidly and with the high increase in exports currently is the most important sector in the Turkish company-GDB, employment and exports.

The Turkish Textile and Apparel Sector at present comprises:

9.5% Gross National Product (GNP)
12% ofmanufacturing sector production,
32% of consumer goods production,
2 1% of manufacturing sector employment
38% oftotal exports. This figure rose with an increase of 198% in four years (between 199 1 - 1995). In textile exports Turkey is 15th among the leading textile and raw materials exporting countries ofthe world with $2.5 billion worth of exports and has a share of 1.7% in the total world.

Within this frame, the selection ofthe enterprises has been done according to both market regions and sub sectors. As a result ofthis, 6 enterprises which were located in Istanbul, Bursa and Corlu were chosen.

The training and other necessary supports are provided by DTI (Danish Technological Institute) for this project. The training has been integrated with conducting the cleaner production audit at the enterprise level. The CP audit and training methodology have been carried out between July 1997 - July 1999 throughout this period.

Anew project on cleaner production implementation has also been undertaken starting from February 1999 for a two-year period. The CP options that will be investigated are on wastewater management and chemical substitution by applying best available technologies (BAT).

Implementation of CP in Turkish Textile Industry

At the first phase of CP where planning and organisation phase takes place, the main problem that was faced was the commitment of management and their involvement. Since CP concept has been introduced to Turkish industry for only two years, special emphasise was given to commence CP. During the establishment of a project team, the background of the team members was taken into account. For each factory, an environmentalist and a textile expert work in parallel for the implementation of CP methodology. During the establishment of the goals, priority was given to the economy and to the market level of the enterprise. The latter belongs to the geographical conditions of the enterprise. Moreover, the reason for the barriers was due to the unawareness of the enterprise about CP concept. Of course utmost importance was given to the implementation of the regulations. After achieving success in this phase, the pre-assessment phase was integrated.

The biggest difficulty faced throughout the pre-assessment phase was the reliability of the data collected. Therefore the verification of data has to be achieved during the evaluation of inputs and outputs. Moreover, in selection of CP options the established goals have to be taken into account together with the involvement of the management. The pre-assessment phase was integrated into the assessment phase. During the walkthrough, the obvious losses were identified. In addition to this focus, points to set the CP options were identified.

As the team started to work on assessment phase, the core of the CP assessment, material balance for the selected recipes were evaluated. The recipes were selected taking into account both the discharged wastewater; its characteristics and energy consumption within that process. The material balances presented the bases for the screening of CP options. In addition to these, the situation of the enterprise from the point of economic, environmental and technological benefits are also considered.

With the screened options the feasibility phase was realised. Depending on the evaluations made, additional data were collected and comprehended to conclude this phase. The implementation and continuation phase has not been carried out yet.

Evaluation of the CP Implementation

During the pre-assessment phase, obvious losses are grouped as follows:

Energy losses weremostly related to inefficient insulation, and excess steam consumption due to not having any equipment for its control and the humidity control in the stenters.

Water consumptionproblems were about the spills on the floor, and excess amount of water consumption for the cleaning of the floor.

Working condition evaluations resulted in the improper storage of chemicals, and solid wastes generated.

After focusing on the CP assessment, the CP options were evaluated taking into account both the material balances and source and cause effects. Along these lines, a list of comprehensive set of cleaner production options were, generated which were listed in order of priority. The prioritised CP options that were grouped for the two of the factories can be as follows:

For a cotton textile plant working under 100% commission:

Since there is the problem ofwater shortage in the location area ofthis specific textile plant, most ofthe CP options were related to this problem. However, in addition to this, energy recovery is also investigated. The CP options which are worth studying for their feasibility can be summarised as:

a) Decreasing the liquor ratio in rinsing baths for water conservation

b) The blowdown from the boilers is directly discharged into the wastewater treatment plant and can be fed into a heat exchanger for its heat recovery.

c) Reuse of treated wastewater in certain processes. For example in prewashing ofprinting screens.

d) Optimisation in regeneration process ofraw water.

Feasibility study for one of the CP options resulted as follows:

CP option: Optimisation in regeneration process of raw water.

Description: During the regeneration process, hardness is almost zero after 43 min. However, the process is ended in 62 min. Therefore, not only process time of 19 min can be saved but also 3 m^3/process water conservation can be achieved. In case of2 regeneration process applications in one day, 6 m^3/day water can be saved. During the calculations it is assumed that wastewater amount changes between 0.8 timesofprocess water. Also the enterprise hasto pay 0.3884 DM/m^3 to Istanbul Sewage and Water Organization.

Net Income: 10.77 DM/day.

Others: There will be labor work reduction by 0.7 DM/day.

		Before implementation	After Implementation	Saving	Environmental Evaluation
inputs					
Electricity	(Kwh/d)	880.2	877.2	3	Energy conservation
Chemical	(kg/day)	1924	1916	8	Reduction of chemicals in wastewater treatment
	(DM/day)	291.4	290	1.4	
Water	(m^3/day)	1800	1794	6	Water conservation
	(D-day)	1818	1810	8	
outputs					
Chemical	(kg/day)	1163	1156	7	Reduction of chemicals in wastewater treatment
	(DM/day)	161	159	2	
Wastewater	(DM/day)	1177.7	1171.7	6	Reduction in wastewater

For another cotton textile plant which consists of integrated process chain:

The screening ofthe CP options for the feasibility phase is evaluated due to the current economic status of the enterprise. The prioritised CP options are listed below:

a) Omitting overflow washing, neutralisation and softening for the bleaching and dyeing processes.

b) Reuse ofprocess water discharged from reactive dyeing ofcotton fabric and yarn.

c) Optimisation ofregeneration system in softening units.

d) Implementation of plate and frame type heat exchanger systems for the dryers and stenters.

The Feasibility Study for one of the CP options is evaluated as below:

CP option : Omit overflow washing, neutralisation and detergent from bleaching and dyeing processes

At the rinsing step of reactive dyeing of cotton, consumption of water, chemical and energy are very important, Water consumption at the rinsing step is approximately 200 l/kg textile. Also because of chemicals, COD load is very high at wastewater. The research showed that neutralisation and usage of detergent do not have a positive effect on the fastness offabric. As a result ofthis case study, recipe which is used at the mill and our recipe which is 3 rinsing steps at 95°C after dyeing process had been applied to the dark and medium shade dyeing at same fabric. During the process, pH was measured. To assess the quality of the dyed textiles the dyehouse ordinary quality assessments were used which are washing, water, wet rub and dry fastness. As a result ofthe comparison with customer sample it was assessed that colour and shade were the same. Quality offabrics is same.

Finally, with high temperature rinsing, the number ofbatchrinses was reduced. For this reason water and energy consumption was reduced. Also neutralisation and usage of detergent can be cancelled since there is no effect on quality offabric.

In addition to this, the case story of the related enterprise can be summarised as below:

Company Name: First Textile
Production: Knitting, yarn and cotton dyeing (cotton, PES, Co/PES) and printing
Background: First Textile was founded as a plant of ORSA Group 1992 in Corlu basin.
Production area of First Textile is knitting, dyeing, printing and finishing. The factory produces 1.600 ton/year of cotton knitted, 4.500 ton/year of dyed cotton fabric, 880 ton/year of dyed yarn and fibre, 940 ton/year printed cotton fabric. First Textile was certified in accordance with the Eco-tex 100 norm.

Environmental Problems : Because of wet processing, water and energy consumption are very high. Also liquor ratio at bleaching and dyeing process, water and chemical usage very high. Also there is bad housekeeping

CP Options:

Identified Options:

1. Wastewater heat exchanger system is not used properly. Also tank capacity of hot wastewater isn't sufficient.
2. There are residual moisture measuring unit output of stenters. But these are not used. Moisture control of fabrics is made manually.
3. Some dyestuffs that are used in fabric and yarn dyeing contain heavy metal. In many cases it is possible to substitute dyes not containing heavy metals.
4. Optical brightness that is used for full bleaching process or pretreatment process before printing contains stilbane derivatives. These are hazardous chemical compounds.
5. Reduction of liquor ratio
6. There is odor problem at the printing kitchen
7. Neutralization may be omitted after dyeing.
8. For taken print paste, they use scrubbers; some of paste is spilled.

Implemented Options

1. Omit overflow washing, neutralisation and detergent from bleaching and dyeing processes.
2. Reuse backwash water for sand filtration and active carbon filtration of ground water after sedimentation
3. Heat recovery from process - waste heat with condensation (air - water)

Option	Environmental Benefits	Cost (Investment & Operation Cost)	Saving ($)	Payback Period
1	Reduction of water energy and chemical consumption	0	58,340 32,370	No investment
2	Reduction of water and salt consumption	$20,000	57,680	3 month
3	Reduction of steam and consumption Air pollution control	$328,820	513,000	1 year

At each phase necessary checklists are used to evaluate the current situation ofthe work carried out. On the top ofany CP option, nothing can be implemented ifany diverse effect was observed on the quality ofproduct. For the managers, the market potential ofthe product, has priority.

During the application ofCP, it was observed that both enteprises were not so careful and sensitive about good housekeeping.

Conclusions

The application ofthe CP concept on any industry has to include both the processes and associated water and energy use. The managerial commitment ofthe enterprise is ofutmost importance in each phase ofCP. Steadily tightening environmental regulations towards production indirectly encourage CP application. Implementation of CP in any industrial sector will definitely support sustainable development. The successful application ofCP in the Turkish textile sector will encourage the other industrial sectors to take similar actions.

Cleaner Production Using Intelligent Systems in the Pulp and Paper Industry
(Adrian Steenkumer, Environment Canada)

Artificial intelligence (AI) was introduced in the mid-1950s to define a branch of computer science researching the development ofintelligent machines. Major subfields in the 1990s include robotics, computer vision, speech synthesis and recognition, natural language processing, automated learning and reasoning, neural networks, and expert systems.

Intelligent systems (IS) are computer software that help operators to control and monitor processes to become more cost effective while improving overall efficiency. There has been proven real-life performance in productivity control, monitoring and diagnosis, scheduling and planning, quality improvement, and energy efficiency.

Intelligent systems have been used at the Burnaby Municipal Solid Waste (MSW) Incinerator to improve production, and to reduce emissions, energy usage, and landfill requirements at a MSW incinerator. The Burnaby MSW Incinerator is located in South Burnaby, British Columbia and 240,000 tonnes ofgarbage are burned there each year producing 700,000 tonnes of steam (two thirds of which is sold to a nearby paper board plant).

An initial broad-based study identified the following four areas where advanced control concepts could aid the plant operations: in the pre-combustion module, to promote more uniform mixing of the MSW, feeder hang-up or upset; in the combustion module, where advanced warning of impending boiler upsets, minimized NOx emissions, particulates, and increased combustion and boiler efficiency; post-combustion module, for more consistent compliance, reduced resource consumption, better fly ash handling characteristics, and better prediction of abnormal conditions; and, the steam side module for faster response to fluctuating demands from the steam consumer.

In the pre-combustion module, the installation of expert system controls allowed the operators to predict when the furnace combustionwas disrupted by feed hang-ups such as wet fuel or fuel transport system blockage. In the post-combustion module, expert systems have reduced lime injection by 6%, reduced baghouse pulsing by 25%, and resulted in lowering overall operating costs with an estimated payback time of 3 years. Stack emissions for the incinerator are outlined below:

Stack Emissions

Pollutant	*Emission Limit*	*1994 Actual Emissions*
Particulates	***40*** mg/m^3	2mg/m^3
Hydrogen Chloride	***55*** mg/m^3	***20*** mg/m^3
Hydrogen Fluoride	***4*** mg/m^3	<0.05 mg/m^3
Sulphur Oxides	***200*** mg/m^3	***80*** mg/m^3
Total Hydrocarbons	36 mg/m^3	***0.4*** mg/m^3
Carbon Monoxide	380 mg/m^3	***8*** mg/m^3

Trace Metals

Cd, Hg, Ti	0.2 mg/m^3	***0.038*** mg/m^3
As, Co, Ni, Se. Te	1.0 mg/m^3	***0.007*** mg/m^3
Sb, Pb, Cr, Cu, Mn, V, Zn	5.0 mg/m^3	***0.045*** mg/m^3

Intelligent systems have also been used in the pulp and paper industry to increase production, lower operating costs, and to reduce energy consumption, pollutant emissions, wastes and waste by-products.

The Canadian pulp and paper industry is the fourth largest paper and paperboard producer, the second largest pulp producer and four out of every five tonnes of paper are exported. Total production of paper, paperboard and commercial pulp is over 29 million metric tonnes (1997 statistics) with estimated earnings of $800 million. Sales of forest products total $52.3 billion, and this industry produces Canada's largest net international trade balance of $30 billion (twice the next largest sector). The direct industry employment is 253,700, while indirect employment is 76 1,000. Available forest resources measure 417.6 million hectares, 7 1% of which are owned by the provinces, 23% by the federal government and 6% by private land owners.

Between 1989 and 1995, this industry spent $5.1 billion on environmental improvements, $1.5 billionto improve recycling capacity, $5 billion on new technology and equipment to reduce emissions and effluent wastes, and $88 million on research to develop closed cycle technologies. As a result, water consumption per tonne has been cut in half from 20 years ago. In the last ten years BOD has dropped 10 fold, TSS has droppedmore than half, the use ofchlorine dropped 87% since 1988, dioxin and furan emissions are down 99% since 1988, and biomass now provides 53% of industries fuel.

A three-phased approach was used to realise these environmental targets. Phase I consisted of an evaluation ofexistingprocess controls, the identification ofexisting control mechanisms, rating the potential for IS application, identifying economic and environmental benefits, and identifying the software and hardware requirements. Phase II consisted of the installation of the IS control mechanisms, the activation and monitoring of the IS system, and refining the IS system parameters, Phase III involved the commercialization of the IS system for other pulp and paper mills, and the investigation of the application of IS systems in other industries.

IS application areas covered in Phase I included recovery boiler optimization, sludge dewatering, emission monitoring and control, and steam leveling for batch digest&s. The next steps in the project involve summarizing and producing a report based on data obtained during a mill visit, presenting the report to the Pulp Mill Management and obtaining funding approval, assisting in preparing applications for various government funding programs, and establishing a collaborative research and development agreement.

Key issues include obtaining background data and information for future comparisons, prioritizing the IS applications, economic and environmental, and ensuring that applications are transferable to other pulp and paper mills.

Future work will involve demonstrating the benefits of an IS application in the pulp and paper industry, investigating the potential for using an IS approach in other sectors (e.g., mining, steel, oil and gas, etc.); establishing linkages with other research and development institutes; and international dissemination ofinformation on developed technologies.

Pollution Prevention Development and Utilization - A History to 2000
(Michael Overcash, North Carolina State University)

With approximately 20 years of pollution prevention development in the U.S. and certain countries of Europe, it is timely to assess the progress of clean technology in specific industrial sectors, such as textiles. As a NATO project, that could involvevirtually all participating countries, this project represents animportant joint effort to document the development and identify areas of consistent success. This project does not involve capital investment nor significant operational costs and thus is suitable for the current NATO/CCMS Clean Processes Pilot Study.

In this project, we seek to establish a concise picture for cleaner technology and textiles pollution prevention of

1) the defining events (conferences, benchmark projects, leading industry, etc.)
2) legislation, and financial investments that have led to the current pollution prevention activity in each participating county.

All participants will collect standard data on their country clean technology program. Special influences that have helped the pollution prevention activities should be noted. These are often cultural, but could be of substantial interest to such a history.

An editorial committee (about three persons) will assemble all inputs and provide the NATO report. It is anticipated that several iterations of information will be collected over 5-7 years as the history project is reviewed at each NATOKCMS meeting. For example in year 2 the emphasis will be on another industrial sector to be decided by the pilot project members. In this way we can create an increasingly informative document, assure that each country can participate, and allow the project members to control the progress each year.

Professor Overcash circulated two draft questionnaires to all attendees for collecting information on cleaner production developments and utilization in general in each country and clean products and processes within the textiles industry.

The structure of the project will be as follows:

Each country will have a primary contact with responsibility for collecting information using the questionnaires but should also use a small group of experts within their country.

Each NATO/CCMS meeting will be used to suggest and improve the draft information questionnaire for each year.

The editorial committee will disseminate the information collected in the prior year and set up an agenda ofinformation to collect the following year thus setting up an iterative process.

A vote will be taken on a schedule for reports in each year to be circulated before the NATO/CCMS meeting.

Professor Overcash will collect and edit the collective reports and then use a committee of four individuals for review.

Cleaner Energy Production With Combined Cycle Systems
(Aysel T. Atimtay, Middle East Technical University, Ankara, Turkey)

Today in the world there is an ever-increasing demand for electrical energy due to the increase in population and economic developments. In order to meet this increasing demand in energy, new sources of energy as well as increased efficiency in present energy production technologies, are being researched.

Professor Atimtay began by comparing global fuel consumption between 1969 and 1994 when it effectively doubled from 4.6 gigatone oil equivalent (Gtoe) to 8.0 Gtoe. By 1996 the ultimate recoverable fossil fuel reserves in the world totalled 4,400 Gtoe. She then outlined the ultimate recoverable fossil fuel reserves in Turkey which are comprised mainly of coal and lignites (approx. 10,000 x 10^6 tones) and natural gas (14,103 x 10^6 m^3).

The development of new technologies to generate clean energy also has a great concern for pollution prevention. Electrical energy is one of the most favorable clean energies and it is generally produced by conventional systems known as pulverized coal-fired or stoker-fired boilers with steam turbine and generator systems. In these systems, the energy conversion efficiency is around 30-35%. This means that only about one-third of the heat generated can be converted to electrical energy.

Among the new technologies developed to generate electrical energy more efficiently, the Integrated Gasification Combined Cycle (IGCC) system is one of the most promising. Figure 1 illustrates the main processes

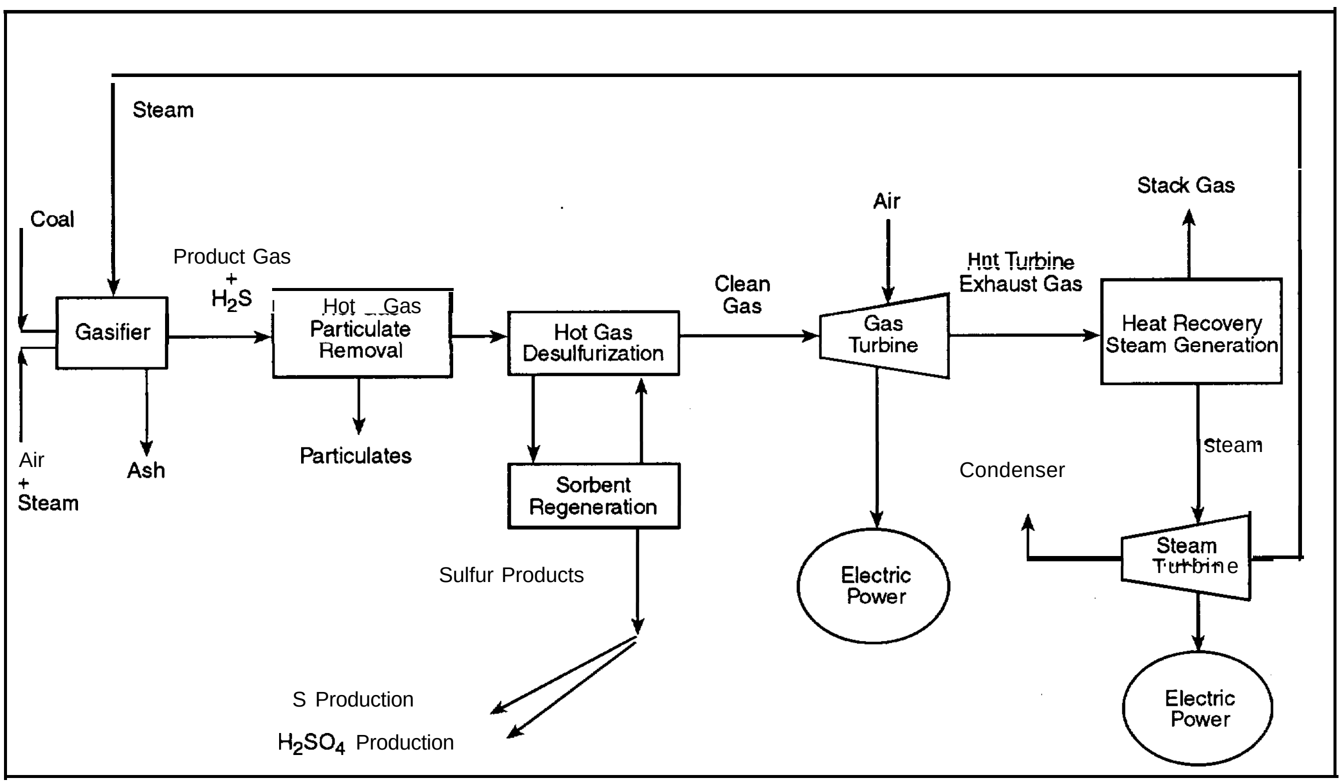

Figure 1. Schematic IGCC flow diagram.

involved in the IGCC system. The current conversion efficiency of the system is 42-43%, which is considerably higher than the conventional systems. This is expected to rise to 45% by 2000, 52% by 2010 and over 60% by 2020. The advantages of IGCC systems over the pulverized coal-fired power generation systems are their higher power generation efficiency, lower air emissions, smaller amounts of solid wastes, lowerwater consumption, simple plant configuration, and capability for staggered/phase construction. The goals of the system are outlined in Table 1.

Table 1. IGCC Goals (De Moss, 1997)

	2000	2010	2020
NO, (lb/MBtu)	0.80	0.07	0.06
SO, (lb/MBtu)	0.20	0.17	0.15
Particulate Matter (lb/MBtu)	0.020	0.015	0.010
Efficiency (%)	45	52	60
Cost ($/kW)	1,350	1,050	**1,100**

Professor Atimtay emphasized the importance in IGCC systems ofcleaning the exhaust gases with special sorbents. These sorbents need to be regenerable to be environmentally friendly.

Professor Atimtay then summarized her research findings about the development of sorbents used for gas cleanup of IGCC systems. The objective of the work is to develop novel sorbents for use in hot gas cleanup systems. Sorbents should have:

High capacity and sulfidation efficiency (for H_2S removal)

High attrition resistance (for fluidized bed applications)

Good regenerability

Resistance to high temperatures (850 - 900°C) in both oxidizing and reducing atmospheres

The types of sorbents researched included iron-based sorbents; zinc-based sorbents such as zinc ferrite, zinc ferrite -vanadium, and zinc titanate; copper-based sorbents; and, manganese-based sorbents. The types of reactors researched included fixed bed reactors and fluidized bed reactors.

Professor Atimtay then explained how zinc ferrite behaves. Zinc ferrite is produced according to the equation:

$$ZnO + Fe_2O_3 \rightarrow ZnFe_2O_4$$

ZnO has a very favorable thermodynamic equilibrium with H_2S and Fe_2O_3 has an easy regenerability with air. ZnO can be combined with Fe_2O_3 to produce $ZnO \bullet Fe_2O_3$ with H_2S removed down to 1 to 5 ppm. The theoretical sulphur capacity is 40% and the actual sulphur capacity is 12- 16%. The following chemical reactions with zinc ferrite were outlined:

Sulfidation $ZnFe_2O_4 + 3H_2S + H_2 \rightarrow ZnS + 2FeS + 4H_2O$

Regeneration $ZnS + 2FeS + 5O_2 \rightarrow ZnFe_2O_4 + 3SO_2$

Figure 2 illustrates a one-inch sorbent screening unit in which Cu-Mn oxide and Cu-Mo-Mn oxide sorbents were tested. Tables 2 and 3 outline metal loading results for improving the impregnation method and the results of efficiency calculations for different sorbents. Finally, Table 4 outlines the zinc content of fresh and sulfided sorbents.

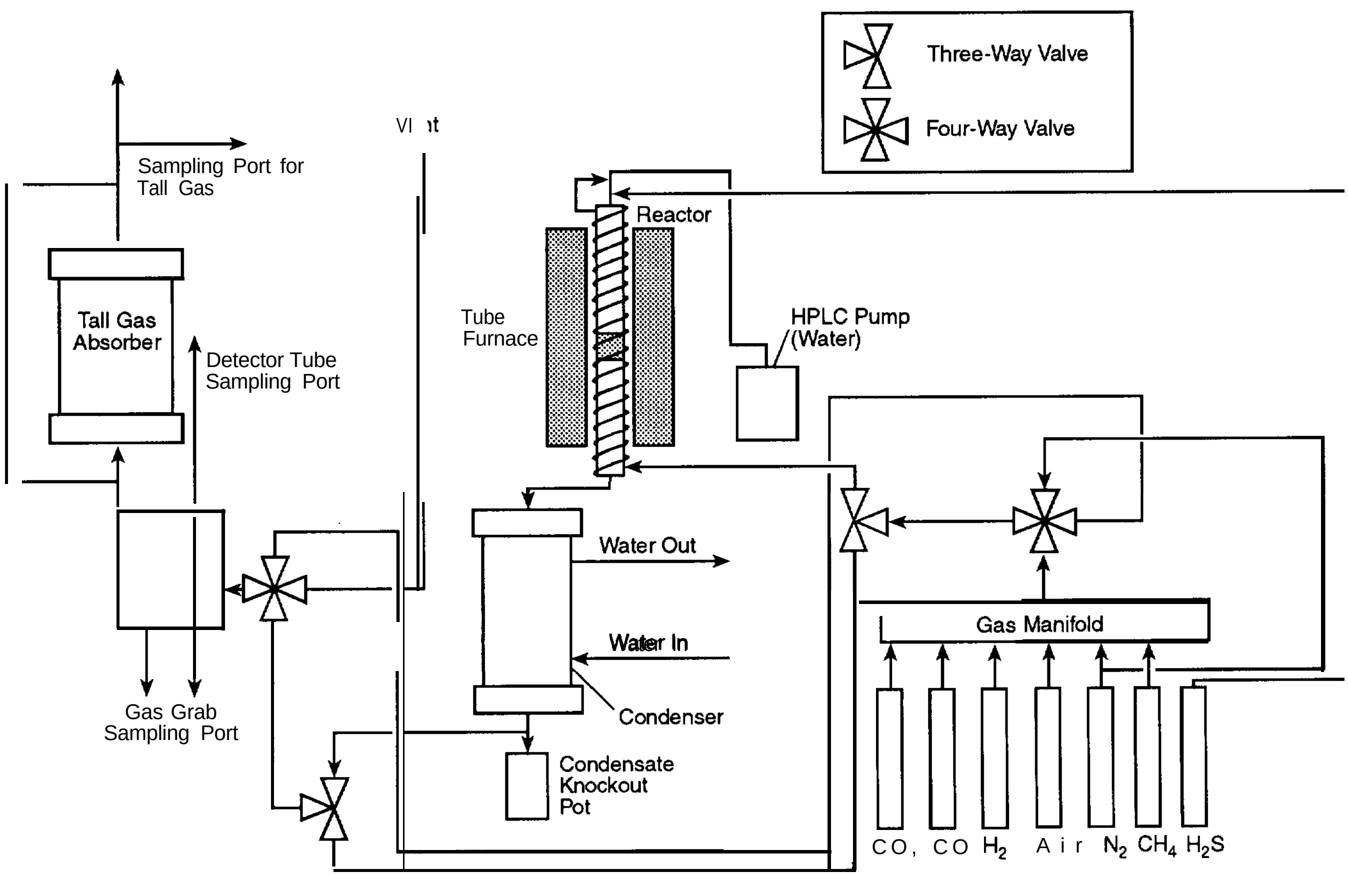

Figure 2. One-inch sorbent screening unit.

Table 2. Metal Loading Results for Improving Impregnation Method

	Zn (wt%)	Fe (wt%)	v (wt%)
Unmodified Conditions	11.66	18.22	3.53
Modified Conditions	8.75	15.88	2.87

Table 3. Results of Efficiency Calculations

	Zn-Fe-O Sorbents		Zn-Fe-V-O Sorbents	
Temp. (°C)	Sulfur Capture Efficiency (%)	Assumed S Capture by Zn and Fe (mg)	Experimental S Capture (mg)	V Contribution to S Capture (%)
600	81.7	3.09	3.54	12.71
650	35.0	1.31	0.3	
700	85.0	3.06	2.0	

Table 4. Zinc Content of the Fresh and Sulfided Sorbents

	Zn-Fe-O Sorbents		Zn-Fe-V-O Sorbents	
	Zn (wt%)	%Zn Loss	Zn (wt%)	%Zn Loss
Fresh	7.53		6.87	
T=600°C	7.14	1.77	6.29	4.69
T=650°C	7.00	5.7	6.55	4.00
T=700°C	6.81	6.1	6.70	0.17

Pollution Prevention Technology Transfer at the U.S. EPA

(Daniel J. Murray, Jr., Technology Transfer Branch, U.S. Environmental Protection Agency)

The U. S. Environmental Protection Agency (EPA) implements many programs in its attempt to protect and enhance the health of its citizens and environment. The Agency's Office of Research and Development provides the scientific and engineering expertise to support these programs. One of the key aspects of EPA's research and development program is its technology transfer program. It is the technology transfer program that delivers the results of EPA's research and development activities to a wide range of users.

The lead organization for EPA's technology transfer activities is the Center for Environmental Research Information (CERI) which is a functional unit in the National Risk Management Research Laboratory. For over twenty-five years, CERI has been producing highly technical documents and meetings to deliver user-focused information and guidance on a multitude ofenvironmental assessment and management topics. The original focus was to provide technical design guidance for domestic wastewater treatment plants, but this evolved into a multi-media and multi-disciplinary program. CERI currently provides a wide range oftechnical and scientific products including: seminars, conferences, workshops; manuals, handbooks, special reports; and electronic and PC-based products.

Over the past ten years, CERI has produced a wide range of products that address the application of pollution prevention as a means to reduce and prevent pollution. CERI has produced numerous pollution prevention documents, starting with the *Waste Minimization Opportunity Assessment Manual* published in July, 1988, that have assisted industrial and commercial sectors and municipal, state and federal governments.

CERI has produced and still disseminates nearly thirty *Guides to Pollution Prevention.* These documents are industry-specific guidance tools for assessing and implementing pollution prevention in the following industries: pesticide formulation, paint manufacturing, photoprocessing, fabricated metal, automotive repair, printed circuit boards, fiberglass/plastics, printing, marine repair, hospitals, pharmaceuticals, and research institutions. Process specific technical guidance has focused on organic coating removal, organic coating alternatives, cleaning/ degreasing, and alternative metal finishes.

CERI published the *Facility Pollution Prevention Guide* in May, 1992 and the next generation pollution prevention guide will be published later this year. Also, there is an *Environmental Management Systems (ISO 14000) Products and Energy/Pollution Prevention Assessment Manual* currently under development. A lot of these products are aimed at small and medium-sized enterprises.

In September 1996, CERI published one of its newer guides, *Manual- Best Management Practicesfor Pollution Prevention in the Textile Industry*. The manual is a government, academia and industry cooperative effort comprised of the U. S. Environmental Protection Agency, the North Carolina State University, the University of South Carolina, the Auburn University, the American Textile Manufacturers Institute, and 3M. It addresses the following:

- waste characterization and prioritization;
- general pollution prevention approaches;
- pollution prevention in specific textile processes;
- implementation of a pollution prevention program;
- pollution prevention incentives and overcoming barriers to pollution prevention; and
- case studies of pollution prevention in the textile industry.

CERI's pollution prevention technology transfer products are available via its *Technology Transfer Highlights* newsletter and web site. The web site can be visited at www.epa.gov/ttbnrmrl or via the EPA web site at http://www.epa.gov.

Conclusion

Open Forum on Clean Products and Processes
(Subhas Sikdar, US. Environmental Protection Agency)

Dr. Subhas Sikdar facilitated an open forum at the end ofthe conference where delegates discussed the structure ofthe pilot program and plans for the future.

Dr. Sikdar opened the discussion by suggesting that the format oftheconference be reviewed inlight ofthe time spent updating delegates on the status of research projects underway in the pilot program. There are currently 8 ongoing projects; if, as expected, this number increases, creative time management will be vital to ensure delegates are continuously updated on all ofthese projects.

Dr. Sikdar then asked ifthere were additional proposals for research projects. He reminded delegates that a written summary of such proposals should be submitted to him which fit the prioritised list oftopics as agreed at the first pilot program meeting in Cincinnati. He encouraged countries to join in collaborative research projects.

Mr. Vladimir Dobes (Czech Republic) reiterated his request for a comprehensive database of clean technologies. Dr. Sikdar suggested the possibility ofproviding a central site for a database with links to other established relevant sites via the internet. He also raised the issue of quality control over included data. Professor Forgacs (Israel) suggested that data could be included with a warning that it is not peer reviewed. Mr. DanielMurray (U. S. EPA) referred to ENVIROSENSE a huge database which does not always give specific technical data. John Stewart (U.K.) agreed with this stating that while there is muchuseful information on pollution prevention case studies within industries on the web, hard data is often lacking. Professor Michael Overcash (U. S. A.) stated that the available data is helpful depending upon on its intended use. Case studies on pollution prevention in specific industries can be useful in showing how particular roadmaps were developed and implemented successfully. Dr. Henrik Wenzel (Denmark) emphasized what was really essential was the provision of aNATO contact point for clean products and processes with links to other sites. Mr. Murray emphasized that the continuous maintenance of a large database is a huge undertaking.

The possibility ofproviding a database ofclean technologies with some quality control, located at U.S. EPA, will be investigated further by Dr. Sikdar and Daniel Murray. This will take the form of a central node with links to other sites. A marker system could indicate data quality, i.e., peer reviewed. This database would be structured in terms ofindustrytype, processes, state oftheart methods, and other contact points, Mr. DanMurrayand Dr. Horst Pohle (Germany)will put together ajoint research proposal on developing a database on cleantechnology.

Dr. Sikdar then addressed the issue of encouraging partnerships among nations in projects which would be ofinterest to the pilot program. He acknowledged that such partnerships were already emerging as a result of networking at the conference. The main objective ofthepilot program is to encourage suchlinks throughtechnology transfer, consequently Dr. Sikdar encouraged participants to publicise these links in writing to his office so they can be further supported. Dr. Sikdar explained that some agencies are willing to fund programs that support collaborative efforts. Such funding could support events suchas intermediary meetings or study visits which would be necessary for collaborative projects. Potential sources of support include NATO CCMS, NATO Sciences for Stabilization, EUREKA, UNEP and UNIDO, U. S. AID and U. S. AEP, U.S. EPA, Danish EPA, NSF, JICA and RITE.

The delegates then agreed that the next meeting of the pilot program would focus on one speciality topic. The structure of the meeting will consist of an expert presentation on the topic followed by an in-depth panel discussion. The textile industry is still first priority. The panel discussion will be the focal point for discussing issues, including state-of-the-art technology, in the textile industry. There will be an information package circulated prior to the meeting, Dr. Wenzel suggested that the informationgenerated during the meeting should be captured in the NATO database. He and Mr. Adrian Steenkamer (Canada) have already agreed to collaborate on a research project involving the development of a pilot database on textiles.

At the next meeting there is also the potential of having workshops on clean product design and tutorials on the efficient use ofdatabases and on the QUESTOR model ofindustry-university collaborative research.

Professor William Zadorsky (Ukraine) emphasized that only specific types of cleaner production technologies are suitable for implementation in countries with transition economies and he added that the Ukraine has huge problems with the use ofbenzene in fuel. It was agreed that these topics warrant much attention and could be the focus of another workshop. This may mean parallel workshops and increasing the overall length of the conference.

Dr. Russell Dunn (U.S.A.) made the observation that the delegates are mostly from academia and government agencies and he strongly recommended that industry become more involved given the success of the pilot program depends on the cooperation of industry. He suggested that the Industrial Advisory Boards (IAB) of the various countries be invited to the next meeting. Contacting IABs or indigenous industries is the responsibility of each delegate.

The next meeting will be held in Copenhagen, Denmark and will be hosted by the Danish Environmental Protection Agency and the Technical University of Denmark. The tentative dates are the 8th to 12th of May, 2000.

Field Trip Summaries

On March 24th, meeting participants visited several locations to observe ongoing technology demonstrations and activities being conducted in Northern Ireland. Tours of the Old Bushmills Distillery and the DuPont Maydown Plant were conducted to show participants the broad range of clean production activities in the area. Also, the participants toured the scenic Antrim Coast and visited the Giant's Causeway, a World Heritage Site, to view this impressive and awe-inspiring geologic formation.

Old Bushmills Distillery

The Old Bushmills Distillery is the oldest operating licensed distillery in the world. In 1608 the distillery was granted a license to distill whiskey. The Bushmills Distillery is located on the edge of the town of Bushmills an hour's drive north of Belfast, Northern Ireland. The distillery uses water from Saint Columb's Rill to make its whiskey. The distillery employs about 100 workers. To enhance the purity of the whiskey, it is triple-distilled. The distillery remains one of the few in the world to distill, blend and bottle whiskey under the same roof.

DuPont Maydown Plant

Work began on the site of the DuPont Maydown Plant in 1958. Currently the plant produces Lycra, beginning in 1968, and Kevlar, beginning in 1988. Lycra is one of the world's leading fashion brands. This ingredient-branded fiber is used in fabrics for apparel, ranging from women's swimwear to men's suits. In 1997, DuPont invested $100 million to expand the capacity to produce this elastane fiber at the Maydown Plant DuPont's Kevlar brand fiber provides a unique combination of toughness, extra-high tenacity and modulus, and exceptional thermal stability, Applications for Kevlar include cut, heat, and bullet/fragment resistant apparel; brake and transmission friction parts; and sporting goods.

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