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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NORTH ATLANTIC TREATY ORGANIZATION

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2001 Annual Report
NATO/CCMS Pilot Study

Clean Products and Processes
(Phase I)

Report Number 253

U. S. Environmental Protection Agency
University of Oviedo
Oviedo, Spain

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NOTICE

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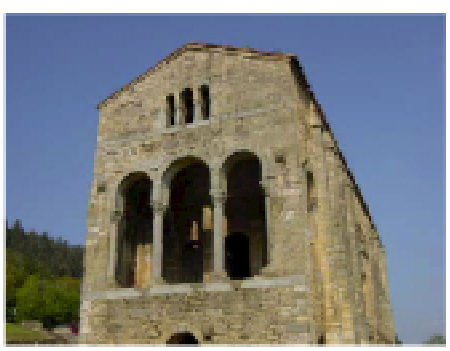
CONTENTS

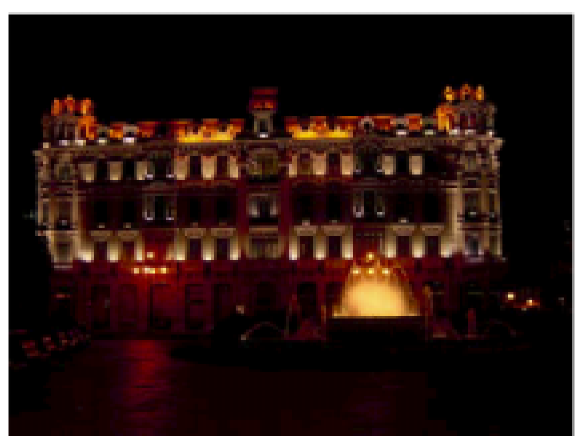
NATO/Committee on the Challenges of Modern Society

PILOT STUDY on CLEAN PRODUCTS AND PROCESSES 4th Meeting May 6-11, 2001 Oviedo, Spain

San Miguel de Lillo



Santa Maria del Naranco



Plaza de la Escandalera

PREFACE

The council of the North Atlantic Treaty Organization (NATO) established the Committee on the Challenges of Modern Society (CCMS) in 1969. CCMS was charged with developing meaningful programs to share information among countries in environmental and societal issues that complement other international endeavors and to provide leadership in solving specific problems of the human environment. A fundamental precept of CCMS involves the transfer of technological and scientific solutions among nations with similar environmental challenges.

The concept of sustainable development, universally accepted as the means of protecting the environment for all mankind, demands that future manufacturing technologies must be cleaner, yet economically sound. With continued industrialization and improving standard of living among nations, and with increasing globalization of markets and means of production, all nations by and large are facing similar environmental challenges in the manufacturing sectors. We established this pilot study on Clean Products and Processes to create an international forum where current trends, developments, and know-how in cleaner technologies, and in tools for measuring their cleanliness can be discussed, debated, and shared. We hope that this pilot study, through its annual meetings, will help stimulate productive interactions among experts, with the expected benefits of effective technology transfer.

The first meeting, held in Cincinnati, Ohio, on March 23-26, 1998, was devoted to creating an agenda for the pilot study. Delegates expressed their views on factors and developments that embody clean manufacturing products and processes. There were several guest lectures on significant developments in government programs, academic and industrial efforts.

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.

The third meeting of the pilot study was held in Copenhagen, Denmark on May 7-12, 2000. This meeting maintained the momentum generated during the first two years of the pilot study, focusing on progress made on several pilot projects being implemented by participating nations and continuing to build a program of collaborative endeavors. This meeting featured a special topical seminar titled “Product Oriented Environmental Measures”, which focused participants’ attention on advances in product design and use. The meeting featured several guest lectures on significant developments in government programs, academic research and industrial applications.

The fourth annual meeting of the NATO/CCMS Pilot Study on Clean Products and Processes was held on May 6-11, 2001 in Oviedo, Spain. The meeting was hosted by Professor José Coca Prados, University of Oviedo, Department of Chemical and Environmental Engineering, Oviedo, Spain. The summary and conclusions reached at this meeting are presented in this report.

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

INTRODUCTION

During the third NATO/CCMS Pilot Study held in Copenhagen on May 7-12, 2000 the delegates attending the meeting suggested that the fourth meeting could take place in Oviedo, Spain. After the excellent meeting in Copenhagen, being hosted by Professor Henrik Wenzel, I was aware of the task that I would have to do in the following year, but in spite of that, I accepted the challenge.

A distinctive feature of this NATO/CCMS Pilot Study is to combine the presentation of research activities (both from industry and university) in the host country, with the presentation of environmental activities and problems in different countries. The ideas and technology transfer that emerge from these meetings may be of particular advantage for the Environmental Agencies of the NATO countries and the Eastern European countries. The latter ones are doing a giant effort to renew their industry with modern technology and with the purpose of reaching a better production efficiency and a better environment.

Clean processes and environmental issues are part on an integrated industrial design, that must be compatible with the rising aspirations of the poor and developing countries for better economic conditions and a higher standard of living. At the same time a key issue for industrial nations is sustainable development: *Development that meets the needs of the present generation without compromising the ability of future generations to meet their needs*. The eradication of poverty and sustainable development will require attention to three main factors: *Quality of life, Natural resources and Environment.*

The Oviedo meeting, with an attendance of 45 participants, was the largest, so far, to the NATO/CCMS Pilot Study. This new NATO/CCMS Pilot Study report reflects most of the topics presented at the meeting. At the end of the report as much information as possible is provided from most of the delegates (picture included), so that it will make easier the exchange of information and contacts with the representatives of different countries.

I am most grateful to companies and institutions from the region of Asturias that generously supported the meeting: City Council of Oviedo, Government of the Principality of Asturias, Bayer, Burdinola, Cajastur, Dow Chemical, and DuPont.

I have to acknowledge some of the members of the Department of Chemical and Environmental Engineering for their unlimited help in the organization of the meeting. I am particularly grateful to Julio Fernández, who took care about the logistics of the meeting, to Prof. José Ramon Alvarez for his help with the financial aspects and to Dr. José Manuel Benito, for his meticulous job of compiling the abstracts and presentations, that ended up as this new report.

José Coca Prados
Professor of Chemical Engineering
Meeting host

WELCOME AND OPENING OF THE MEETING

The fourth annual meeting of the NATO/CCMS Pilot Study on Clean Products and Processes was held on May 6-11, 2001 in Oviedo, Spain. The meeting was hosted by Professor José Coca Prados, University of Oviedo, Department of Chemical and Environmental Engineering, Oviedo, Spain. The meeting was held at the Oviedo Auditorium "Príncipe Felipe", near the city center and old town. Oviedo, with a population of approximately 200,000, is located in the north of Spain, in the central area of the Principality of Asturias. Oviedo is 227 meters above sea level with a moderate climate with mild winters and cool summers.

This meeting includes delegates and participants from 21 nations. On Sunday, May 6, 2001, the opening reception was held and delegates and participants were greeted by Professor Coca and Dr. Subhas Sikdar, Pilot Study Director, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, Ohio.

Isabel Pérez Espinosa greets Dr. Subhas Sikdar and Professor José Coca on behalf of the Mayor of Oviedo, Spain.

On Monday, May 7, 2001, the technical meeting began with an introduction from Dr. Sikdar, introductions of national delegates and participants, and an overview of the meeting agenda, field visits and events from Mr. Daniel Murray, Pilot Study Co-Director, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, Ohio. The first of several special topic presentations was given by Associate Professor Tillman Gerngross, Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire. His though provoking presentation was titled “How Green Are Green Plastics?” In addition, several pilot project updates and “Tour de Table” presentations were given addressing tools for pollution prevention (United States), hydrocarbon emissions from gasoline blending (Portugal), integrated membrane operations (Italy), cleaner production strategies (Ukraine), ceramic membranes (Russia), responsible industrial disposal (Spain), and cleaner production information via the internet (Germany and United States). The day concluded with a poster session and demonstrations of computer-based tools and information systems to support cleaner production.

The technical meeting continued on Tuesday, May 8, 2001, with an overview of programs of the U.S. National Science Foundation given by Mr. Thomas Chapman. The “Tour de Table” presentations continued addressing pinch analysis of chemical processes (Slovenia), industrial ecology (Norway), organizational factors affecting cleaner production (Hungary), reuse of industrial dusts (Poland), industrial treatment with constructed wetlands (Portugal), agrifood industry (Bulgaria and Greece), industrial water management (Denmark), pollution prevention (Romania), and national cleaner production updates (Czech Republic, Israel, and Lithuania). Pilot projects updates addressed using fewer natural resources and meeting peoples’ needs (Moldova), new processes and materials in the semiconductor manufacturing (United States and United Kingdom), and implementation of cleaner production processes in member countries (United States). The day concluded with two perspectives on university-industry cooperation from Professor Coca (Spain) and Professor Jim Swindall, QUESTOR Centre, Queen’s University, Belfast, Northern Ireland (United Kingdom).

National delegates and meeting participants during the tour of Santa María del Naranco

The traditional field trip was held on Wednesday, May 9, 2001, and a special topic seminar was held on Thursday, May 10, 2001. The seminar was titled "Environmental challenges in the process industries". The seminar featured over a dozen local, regional, and national speakers from Oviedo, Asturias, and Spain. The following technical presentations were given: Principality of Asturias environmental policy; Advances in environmental aspects of desalination in the Canary Islands; Environmental progress in Dow Chemical Iberica; Environmental policy and energy consumption – a compromise solution; Lignosulphonates – environmental friendly products from a waste stream; Hydrogen economy and fuel cells – energy for the future; Membrane technology in the pulp and paper industry; Activities and initiatives to support companies and business sectors to improve their relationship with the environment; Treatment of oil-containing wastewaters using clean technologies; New national legislation on environmental quality and clean production; Making carbochemistry compatible with the environment; and Treatment of phenolic wastewaters in the salicylic acid manufacturing process.

Oviedo Auditorium "Príncipe Felipe"

TOUR DE TABLE PRESENTATIONS

PROGRESS AND NEW PERSPECTIVES ON INTEGRATED MEMBRANE OPERATIONS FOR SUSTAINABLE INDUSTRIAL GROWTH

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Membrane science and technology has led to significant innovation in both processes and products, particularly appropriate for sustainable industrial growth, over the past few decades.

The preparation of asymmetric cellulose acetate membranes in the early 1960s by Loeb and Sourirajan is generally recognized as a pivotal moment for membrane technology. They discovered an effective method for significantly increasing the permeation flux of polymeric membranes without significant changes in selectivity, which made possible the use of membranes in large-scale operations for desalting brackish water and seawater by reverse osmosis and for various other molecular separations in different industrial areas. Today, reverse osmosis is a well-recognized basic unit operation, together with ultrafiltration, cross-flow microfiltration, and nanofiltration, all pressure-driven membrane processes. In 1999, the total capacity of reverse osmosis (RO) desalination plants was more than 10 millions m^3/day, which exceeds the amount produced by the thermal method, and more than 250 000 m^2 of ultrafiltration membranes were installed for the treatment of whey and milk.

Composite polymeric membranes developed in the 1970s made the separation of components from gas streams commercially feasible. Billions of cubic meters of pure gases are now produced via selective permeation in polymeric membranes.

The combination of molecular separation with a chemical reaction, or membrane reactors, offers important new opportunities for improving the production efficiency in biotechnology and in the chemical industry. The availability of new high-temperature-resistant membranes and of new membrane operations as membrane contactors offers an important tool for the design of alternative production systems appropriate for sustainable growth.

The basic properties of membrane operations make them ideal for industrial production: they are generally athermal and do not involve phase changes or chemical additives, they are simple in concept and operation, they are modular and easy to scale-up, and they are low in energy consumption with a potential for more rational utilization of raw materials and recovery and reuse of byproducts. Membrane technologies, compared to those commonly used today, respond efficiently to the requirements of so-called "process intensification", because they permit drastic improvements in manufacturing and processing, substantially decreasing the equipment-size/production-capacity ratio, energy consumption, and/or waste production and resulting in cheaper, sustainable technical solutions.

The possibilities of redesigning innovative integrated membrane processes in various industrial sectors characterized by low environmental impacts, low energy consumption, and high quality of final products have been studied and in some cases realized industrially.

Interesting examples are in the dairy industry and in the pharmaceutical industry. Research projects are in progress in the leather industry and in the agrofood industry based on the same concept.

The continuous interest and growth of the various new industrial processes related to life sciences, as evidenced also by the strategies and reorganization adopted by large chemical groups worldwide in this area (*e.g.*, Aventis, Novartis, Vivendi Water, etc.) will also require significant contributions from membrane engineering.

FOSTERING RESOURCE EFFICIENCY THROUGH NETWORKING AND CONVENIENT INFORMATION ACCESS – GERMANY'S CLEARINGHOUSE COOPERATIVES ON CLEANER PRODUCTION IN THE WORLD WIDE WEB

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The access to technology and management information is crucial for further implementation of cleaner production processes in companies. With two new Internet gateways, Germany supports this demand to foster sustainable development in industry. The German Federal Environmental Agency (UBA) has established the first version of the website "www.cleaner-production.de". Cleaner Production Germany (CPG) is a federal Internet information system for innovative environmental technology and federal projects in Germany and a gateway to technology transfer and contacts. The PIUS Internet Forum under www.pius-info.de is closely linked with CPG. It is a cooperative web project of currently five German states with new partners to be acquired. The large database of pollution prevention projects conducted in companies offers detailed information about technology, experiences, costs and management. By extending the two cooperating Internet platforms Germany wants to boost international environmental and development cooperation and promote the transfer of environmental technologies.

CLEANER PRODUCTION STRATEGY AND TACTICS

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Cleaner Production is conceptual and procedural approach to production, demanding that all phases of a product or process life cycle is addressed with the objective of preventing or minimizing short- and long-term risks to the humans and the environment. Cleaner Production utilizes improvements in product design, raw materials production, selection and their efficient use, as well as production and assembly of final products, consumer use of the products, waste and disposal recycling, transportation of raw materials and products, and energy savings. Specifically, adoption of Cleaner Production principles offers industry opportunities to promote operating efficiency while improving environmental performance. Source waste reduction eliminates costly post-production effluent control or bolt-on treatment. This conserves raw materials and energy, eliminates usage of toxic materials and reduces quantity and toxicity of all emissions and wastes in a closed-cycle process. For products, Cleaner Production spans the entire process life cycle from raw material procurement to disposal of byproducts of industrial material processing. Cleaner Production is achieved by applying know-how, by improving technology and changing attitudes. Cleaner Production is generally cost effective due to potential improvements of both process efficiency and improved product quality. These economic advantages of CP are especially evident when compared with other environmental protection strategies, for example such as end-of-pipe wastewater treatment, waste processing, and exhaust gas treatment. Apart from cleaner production in industry, it is possible also to survey opportunities and constraints for cleaner energy conversion and improved energy utilization.

Recently, the main conception of nature protection in the Ukraine was the finding and analysis of human impact on surroundings. Today the situation is changing and this defensive concept is replaced by the new one, the main approach of which is the rebuilding of agricultural and industrial complex. Significant Ukraine's problem is division economic, social and ecological factors within the framework of systems of acceptance of the decisions at levels of a policy, planning and management, that renders significant influence to realization of the concept of sustainable development of the country and first of all - its industrial and agricultural production. The Ukraine needs in environmentally sustainable economic and social development. It is necessary for realization of all complex problems of the integrating of economic, biological and human systems to collaborate between the engine-, info-, mathematical modeling- and eco-communities. Development of sustainable development strategy is expedient, which had two orientations: ecological safety and preservation of environmental natural environment, i.e. development of sustainable social-ecological strategy with use of effective economic gears of satisfaction of requirements of the person. The world experience testifies that the main tendencies in maintenance of sustainable industrial development of an industrial region following development of low- and non-waste technological processes and equipment and salvaging industrial and household waste.

The presentation first part is devoted to some results at cleaner production (CP) theory elaboration and practice of CP theory use. CP strategy and tactics, based on systematic approach to sustainable product development, is described. Main principles of the CP concept are as follows:

- All ecological problems should be solved in cooperation with a unified comprehensive planning
- Ecologizing economy supposes modernization of objects, which are real or potential pollutants of environment
- The prosperity of ecologizing implies existence of professionals skilled in the theory and practice of ecologizing, cleaner production and ecological management
- The creation of civilized ecological market is a necessary prerequisite for ecologizing of economy and sustainable development of the country

As known, the CP concept as and sustainable development concept includes three aspects: ecological, economic and social. Only mutually balanced simultaneous comprehensive tackling of the three tasks (economical growth with simultaneous improvement of ecological conditions and decision of social problems) will allow realizing progressive CP strategy. The system analysis shows strong interaction and feedback among the mentioned three factors of CP strategy.

The set of engineering techniques and methods for Cleaner Production seems somewhat limited and lacking diversity. Meanwhile there are a lot of effective methods to increase product cleanliness. For example, we use the following Cleaner Production tools and methods:

- Recirculating flow of the least hazardous agent taken in excess over its stoichiometric value
- Isolation (close-looping in structure) of flows of substance and energy by recirculating, resulting to “idealization” of modes of synthesis and significant reduction of speed of by- processes
- Controlled heterogenization of the contacting phases for softer conditions and improved selectivity
- Separative reactions: removal of reaction products at the moment of their formation from reaction zone, synthesis and dividing processes organizing in the same place and in the same time), allowing to reduce formation of by-products by removal of a target product from a reactionary zone at the moment of its formation
- Synthesis in an aerosol to increase intraparticle pressure and reaction rate
- Self-excited oscillation of reacting phase flows at frequencies and amplitudes matching those at the rate-limiting tiers of the system
- Flexibility and adaptability of technology and equipment allowing to ensure reliable work of technical system by "internal" reserves (flexibility) of installation using, that reduces an opportunity of harmful substances pollution or reception of a sub-standard product
- Minimization of time of processing and surplus less toxic reagent, resulting all to increase of selectivity and reduction of formation of by-products

CP algorithm will look as a sequence of following actions:

1. DECOMPOSITION. Hierarchy level determination and technical system decomposition. The analysis of the initial information including inspection of industrial manufacture, with the purpose of its decomposition on typical levels of hierarchy (for example, manufacture – plant item - installation –apparatus or machine - contact device - molecular level).

2. IDENTIFICATION of an initial level. Revealing of the bottom level of hierarchy limiting from the point of view of pollution to an environment. Definition of limiting hierarchical level/levels. Herewith reasonable move on the hierarchical stairway from top to bottom and use methods of expert evaluations.

3. SELECTIVITY & INTENSITY INCREASE. Increase of selectivity and intensity of actually technological stages of processing at a limiting level of hierarchy. Choice of CP methods depending on the limiting level scale (defining size) corresponding with parameters of influence method to the system from the database.

The system approach that is demonstrated in the special table is connected tier of system with the frequency order, dimension order, concepts and methodologies and with tools and methods for Cleaner Production. There should be a match between a tier in a hierarchy and the methodology of characterization, assessment or influence used at this tier.

Some tools and methods for CP are described:

- Highest results we have when heterogenization is used as a part of Reactive Separation Processes (RSP) ideology. It is discussed also number of possible mechanisms of chemical reactions improving with increasing of their selectivity when mass transfer process joints with chemical one in particularities at bubbles mode of phases interaction.

- Parallel reactive separation processes (RSP) are using as Clean Reaction Technologies for increasing a purity of production, Waste Reduction and for Pollution Prevention. Usually reactive zone and distillation zone is the separate zone in similar units. But we will have a lot of additional effects if these zones will be combined in joint volume. Then in the reactive-separation zone not only the reaction heat will cause additional mass transfer between vapor and liquid phases but also it will be increase a rate of the chemical process. Laboratory and industrial research revealed that the reaction-separation mode is well-suited for acylation, amidation, amination, condensation, cyclization, dehydration, etherification, halogenation, hydrolysis, oxidation and other chemical reactions

Some of offered by the author of presentation ecologically friendly technological processes, among which many are developed within the framework of CP program for working manufactures, are submitted in the second presentation part as applied database “Commercialized Technologies Virtual Market”.

Third part of presentation is devoted to CP Problems in transition economy countries and to the possibilities of collaboration in the frame of NATO/CCMS Program "Clean Technologies and Products".

It's necessary to have for CP movement development worldwide: clear terms and definitions, general theory, strategy and tactics for CP concept and manual for CP tools and methods, compendium of the best CP practices, economic mechanisms of stimulating for the transition to CP technologies, association, coordination and information of organizations and individuals are dealing with CP. In the same time it is necessary to help the CP movement meet its goals in transition economies as this countries have a lot of development features:

1. Methodology for application of CP philosophy to restructuring, military conversion, privatization and economic transition at a national and regional levels.

2. Practicable program for embodying the CP concept under sweeping changes in the NIS and other transition economies.

3. Restructuring, privatization and military conversion relationship to building an environmentally friendly economy. It would suggest that new environmental and CP challenges in transition economies be discussed.

4. Priority-based investment programs for and attracting investors to NIS.

New environmental and Cleaner Production challenges in transition economies must be included in Cleaner Production concept realization. For example, there are severe environmental effects of restructuring, military conversion, privatization and economic transition. In any case, transition economies have no mechanisms for stimulating Cleaner Production technologies. It is desirable to use the systems approach in Cleaner Production Concept Implementation (or Cleaner Production Strategy and Tactics) for transition economies.

At the same time it is necessary to help Cleaner Production movement meet its economic goals in transition economies which have development features as follows:

1. Methodology for application of CP philosophy to economic restructuring, military conversion, privatization and economic in transition at a national or regional level.

2. Practicable program for embodying CP concept under sweeping changes in the NIS and other transition economies. (May be it is desirable to launch a Special Pilot Project on Systems Approach to CP Concept Implementation (or CP Strategy and Tactics) for Transition Economies. In any case, transition economies have no mechanisms for stimulating CP technologies).

3. CP oriented priority-based investment programs for attracting investors to NIS.

Cleaner Production main goal and objectives are:

1. Systematization of cleaner production general theory, strategy and tactics, search of the tools and methods based on a systematic approach as a foundation of sustainable product development.

2. Searching and elaboration of the economic mechanisms stimulating transition to CP technologies in conditions of transition economy.

3. Organizing of international collaboration, association, coordination and information of organizations and individuals dealing with CP.

Besides we need the specific steps and tasks to be proposed:

Terms and definitions, unification of the terminology of Clean(er) Production

1. Writing and editing in Russian and English a handbook or practical manual of CP.

2. Organizing of an online CP Help and Consulting Service.

3. A compendium of the best CP practices at a pilot project of transportation environmental problem realization for a large industrial city.

4. Launch a CP technology incubator or greenhouse.

Then we can receive some concrete results and expected outcomes:

1. A pilot project for demonstration of transportation environmental problem solving for a large industrial city.

2. Handbook or practical manual of CP practices tools and methods.

3. Review to identify economic mechanisms stimulating transition to CP technologies in conditions of transition economy.

4. Online CP Help and Consulting Service.

5. CP technology incubator (warm house).

Main directions our activities now are:

- elaboration of strategy and tactics for cleaner production, waste management, pollution prevention;
- system ecologizing of acting manufactures;
- development and introduction of methods of adaptation and rehabilitation of the population in conditions of the increased technical loads;
- development and realization of the program of sustainable development of industrial region;
- continuous ecological training and education, based on the concept of active constructive ecology;
- development of the information at cleaner production technology and equipment;

- to demonstrate the economic benefits of pollution prevention and recycling to industry business operations.

For the decision of problems of information exchange it is necessary realize the following programs:

- Creation of computer information base at ecological engineering and technologies of cleaner production;
- Issue a periodic regional ecological electronic newspapers, distributing ecological information and experience of use of cleaner production in regions and in the world (with use of networks);
- Realization of active contacts to world community on exchange by the ecological information;
- Retraining of the experts of acting manufactures on directions resource saving and ecological technologies.

It is necessary to give the main attention not so much to cleaning of gases and liquids as to many non-waste technologies for processing of raw materials including but not limited to concurrent reaction-dividing processes, new effective methods of recycling using capillary and porous impregnation of waste materials, electric aerosol technology, and flexible chemical engineering.

And at last an important advantage in solving ecological problems is interdisciplinary approach via experience of various experts from different organizations with the purpose of the best decision making regarding specific problems.

There are some specific problems in the transition economies that need to be solved. For sample, CP approaches are concerned not only with production but also with transportation. The traffic has dramatically increased in Ukraine due to market development and occurrence of a great many of trade intermediaries and small businesses. This resulted in aggravated negative influence of transportation on environment, making cleaner transport a matter of survival and urging immediate and competent decisions. The "free" market has displaced regular grades of petrol for cheaper ones containing aromatics, that is hazardous byproducts of coke industry. These include benzene, toluene, xylene and others and their combinations. Expert judgment is that these aromatics cannot be burned in an engine completely and are massively discharged to air with exhaust gas. No research into amounts of aromatics in exhaust has been conducted. The analyses of government bodies generally do not include these compounds. Meanwhile, the content of aromatics like benzene in a fuel is limited by standards of advanced countries. The above is not limited to ecology of motor vehicles and is an issue with railway, water and air transport as well, thus being a cross-disciplinary problem. Considering that there are a number of other environmental issues common for all types of transport, a special discussing of scientists and experts on various types of transport is necessary. The main topics are: ecology of vehicles, environmental challenges of engines and fuel, environmental challenges of freight traffic, passenger compartment ecology, ecology of accidents and emergency situations on transport, environmental aspects of transportation infrastructure, environmental challenges of handling cargoes.

Many countries in Europe have declared a shift from municipal waste incineration to other technologies. May it is necessary to discuss results of environmental and economy analyses of waste incineration and processing technologies. It is desirable to organize an Expert-online CP Help or Consulting Service. May be it is possible to launch a CP technology incubator or greenhouse.

It's reasonable to include in NATO/CCMS web site collaboration pages, for examples:

- CP chat for Program participants,
- Announcements,
- Free consulting, expertise, audits,
- Proposals and information about results of collaboration,
- Virtual on-line TECHNOLOGICAL CP BUSINESS-INCUBATOR (VTBI-CP) “INTELLECTUAL SERVICE”. VTBI-CP will be a commercial NET.

We offer a wide program of mutually beneficial collaboration:

- Joint scientific research, including participation in international scientific programs and joint developments for industrial enterprises and other organizations
- Transfer of new high technologies
- Joint analysis of developments in science, industry, education and social policies in the NIS countries
- Joint research in permanent areas of applied chemistry, chemical processing and chemical engineering, chemical industry, metallurgy, engineering, food-processing and pharmaceutical industries
- Exchange of leading scientists and specialists
- Exchange of visiting professors that deliver lectures on the chosen themes

We hope collaboration will be useful and will help fulfill some domestic projects that bring together industry, government, the scientific community and the public to attack challenges in our community by using innovative solutions and appropriate international help.

CERAMIC MEMBRANES IN CLEAN PROCESSES IN RUSSIA

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The development of inorganic membranes in Russia began in early 40-s of XX-th century and the main industrial application was the separation of gases. In the 80-s of the last century various research groups and industrial enterprises were concentrated due to special program, financed by government, for the development of ceramic membranes technology, production and realization of membranes and units. Due to this program the technologies of micro-, ultra- and nanofiltration ceramic membranes based on Al_2O_3, ZrO_2, TiO_2, SiO_2, CeO_2, SiC were developed and various processes and applications were studied. The first industrial output of ceramic microfiltration membranes started in 1989 in Moscow region. The rate of ceramic membranes production in Russia (100 m^2 in 1989) reached 950 m^2 in 1993 and 2 100 m^2 in 2000. Basic industrial applications, designs and technological data of ceramic membrane units for clean products and processes in food industry (purification of wines, juices, vodka etc.), pure and waste waters treatment, microbiological and pharmaceutical branches of industry (filtration of biomass, culture broths etc.) are discussed.

TOWARDS RESPONSIBLE INDUSTRIAL DISPOSAL IN SPAIN

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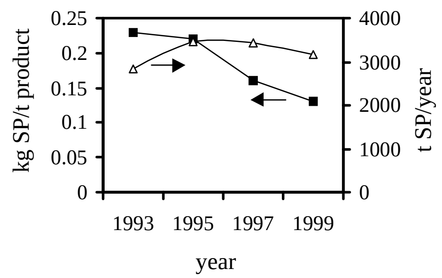
The international program *Responsible Care* was adopted by Spanish industries in 1993. In a recent report [1] 76.4% of the Spanish companies are taking environmental measures to comply with the legislation, and 64% in order to have a better public image. Since the Responsible Care program was implemented, the annual average investment has been 9.300 M pts (58.1 M∈) and 18.000 Mpts (113 M∈) were invested in 1999.

In 1998 there were 135 000 job positions in the area of environment, 30% involved with water management and 29% with waste disposal. By the end of 2001 it is expected that the number of jobs in the environment sector will be of 2000. For most companies environmental issues are the fourth priority, after work safety and energy and materials savings. The larger investments on environmental issues, and number of companies involved, in the industrial sectors has been: (oil refining, plastics, energy plants) (93.1%), transportation equipment (85.3%), chemicals (83.3%) and equipment manufacture (82%). The benefits of environmental investments are considered low by companies, and only 41% of them admit some savings in product recovery or energy savings.

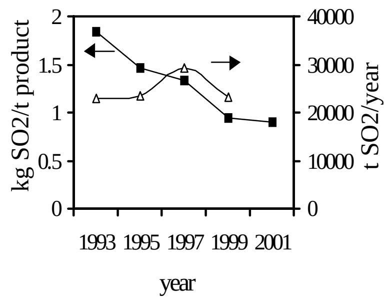
Air pollution

The most important pollutants, which are usually measured as an indication of air-pollution are: 1. Solid particles (fine ashes, soot, etc.), 2. Sulphur oxides (SOx), 3. Carbon dioxide (CO_2) 4. Nitrogen oxides (NOx) and 5. Volatile organic compounds (VOC´s). Air pollution is mainly associated with energy production and consumption, but there are other sources such as industries, agriculture, sprayers, dry cleaners, etc. In Fig.1 the discharge evolution in Spain for the aforementioned pollutants, since 1993, is shown.

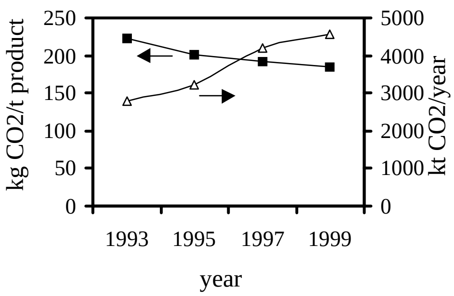
The discharge decrease due to environmental actions, taken mainly by companies using combustion processes, has been very important: 57% for solid particles, 24% for SOx, 40 % for CO_2 and 43% for VOC´s. However, there has been an increase in the absolute value for the NOx emissions, as a result of the increasing number of cogeneration plants.



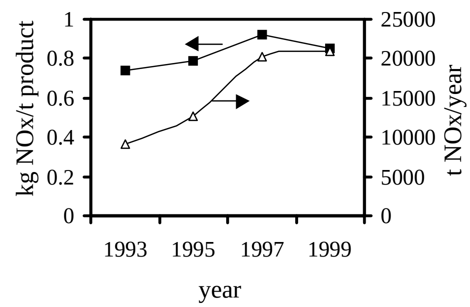
a. Solid particles (SP)



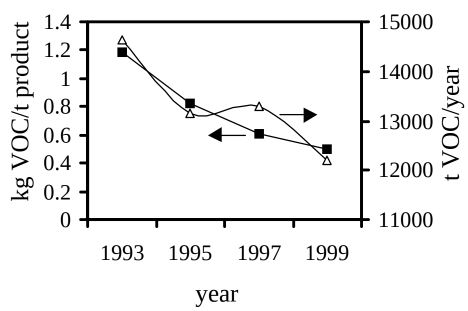
b. Sulphur oxides (SO_2)



c. Carbon dioxide (CO_2)



d. Nitrogen oxides (NOx)

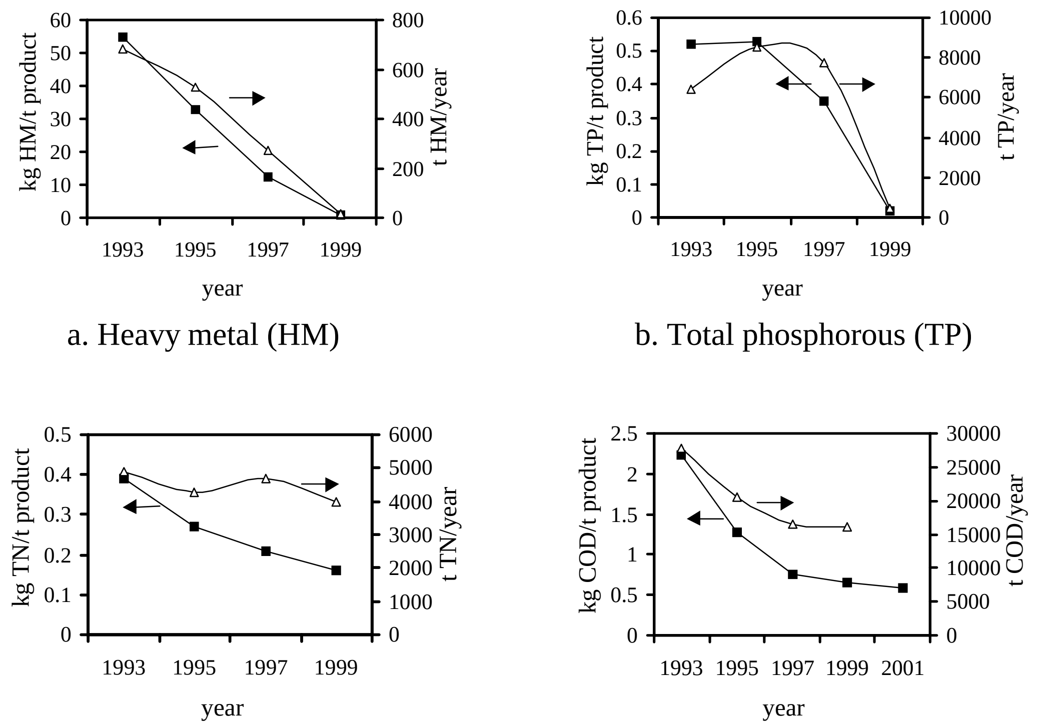


e. VOC's

Figure 1. Evolution of air emissions in Spain since Responsible Care program was established

Water pollution

Most of the industrial processes are designed either to recycle or save water. It is considered that most of the industrial water once it has been used returns to the life cycle (80-90%). The evolution of some important industrial wastewater characteristics is shown in Fig.2. They correspond to effluents from manufacturing and refrigeration processes.



a. Heavy metal (HM) b. Total phosphorous (TP)

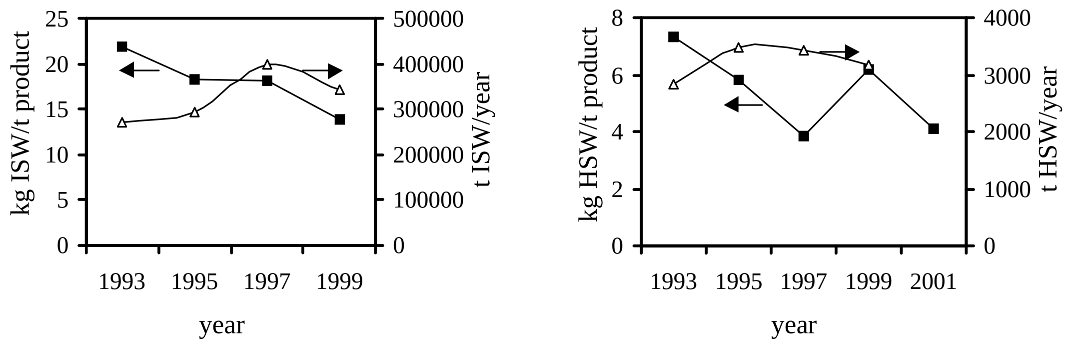
c. Total nitrogen (TN) d. Chemical oxygen demand (COD)

Figure 2. Evolution of wastewater parameters in Spain since Responsible Care program was established

The total discharge of pollutants has decreased by 74% since 1993. The substantial decrease in the heavy metals contents is likely due to the reduction of mercury in effluents from the chlorine-alkali industry. The reduction of phosphorus content since 1997 is due to a more effective effluent treatment and the implementation of clean technologies by some companies. The reduction in the remaining parameters has been: 59% for nitrogen and 70% for COD.

Solid wastes

Industrial solid wastes have a wide physical and chemical nature. They may be hauled in private dumps, disposed of by landfilling and burnt in the plant or in an outside incinerator, if no toxic substances are released. Industrial solid wastes have increased since 1993, but have decreased by 36.8% per ton of product, Fig. 3a. A new law was passed in 1997, to comply with the Responsible Care program, and Fig. 3b shows the evolution of dangerous solid wastes.



a. Industrial solid wastes (ISW) b. Hazardous solid wastes (HSW)

Figure 3. Evolution of solid wastes in Spain since Responsible Care program was established

Membrane processes for cleaner production

1. Pulp and paper effluents treatment

The actual concern about water pollution from industry has moved most of the countries to increase restrictions over effluent disposal. Pulp and paper industry is particularly affected because of its water requirements.

- *Removal of pitch by microfiltration (MF)*. The use of MF to remove pitch form different streams in the pulp production process can lead to an increase of pulp quality as well as the reduction of some problems associated to the accumulation of such matter in the process. Effluents from process waters were fed to a MF pilot plant at a temperature of 70-80 ºC. Pressures up to 5 bar were applied. Complete removal of pitch (98-100 %) was achieved at all tested conditions. Feed velocity was found to have a very important effect on flux.

- *ECF bleaching effluents treatment*. Bleaching stages in the pulp and paper industry are responsible for more than 50% of water pollution. Conventional treatments reduce BOD and COD, but they are not effective regarding colour reduction. In this project different commercial tubular ultrafiltration and nanofiltration membranes are used for the treatment of several effluents from the bleaching plant of kraft pulp. The research has been focused on determining the feasibility of the process in order to utilize it in industrial scale. Results show that nanofiltration is a reliable technique for the treatment of the bleaching effluents and their reuse in the bleach plant.

- *TCF bleaching effluents treatment*. The use of nanofiltration membranes allows the removal of low molecular weight matter (around 500 dalton) as well as di- and tri-valent ions. In the present case, transition metals such as iron and manganese have been removed not in the ionic form in solution, but as a chelate formed with an acetic acid-based chelation agent.

- *Kraft black liquor fractionation*. The most common use of kraft black liquors is as an energy source, being burnt after concentration, in order to produce steam and recover chemicals which are recycled to the process. An alternative process for overflows and spillages might be the recovery of lignin and further use of the fractions, in the manufacture of more valuable compounds. Membrane processes are effective in the separation of lignin fractions and also allow the recovery of salts, that in turn could be recycled to the pulping process. Experiments were carried out in a tubular membrane module, using ultrafiltration membranes. Diafiltration experiments have been also carried out to enrich the retentate in the high molecular weight fraction.

2. *Removal of waste emulsified cutting oils*

Oil refining and metal-finishing industries, such as rolling mills and mechanical workshops, produce large quantities of oily wastewaters that need to be treated before their disposal. The aim of this project is the design and construction of a modular pilot plant for the treatment of different water-based coolants and oily wastewaters generated in metalworking processes and steel cold rolling operations. Different treatments can be carried out depending on the nature of the oily waste emulsion, such as coagulation/flocculation, centrifugation, membrane processes (micro and ultrafiltration) and sorption processes.

The effect of surfactants present in the feed emulsions, is being also be studied, due to their considerable amount present in permeates, yielding an effluent with a high organic content.

Furthermore, the formulation of new water-based cutting fluids for their use in metalworking processes and steel cold rolling operations, which could be reused and/or removed by means of clean and environmental-friendly technologies, will be carried out.

3. *Membrane-based hybrid processes*

- *Phenol removal by pertraction*. The removal of phenolic compounds from waste streams is very important since phenol is present in aqueous effluents from several industries (*i.e.*, petrochemical, pulp and paper, polymer and pharmaceutical). Phenol removal has been carried out by pertraction, a process involving solvent extraction using hollow fiber modules. The limitations of the conventional two-phase separation equipment, such formation of stable emulsions, loading requirements and flooding restrictions can be overcome using a hollow fiber membrane contactor. The organic phase flows on the shell side while the aqueous phase is pumped through the fibers lumen. The study is focused on the influence of hydrodynamics the aqueous and organic phases on the overall mass transfer coefficient. Continuous extraction-backextraction experiments, using two modules to respectively load and regenerate the organic phase, are being carried out.

- *Enzymatic membrane reactors for the production of lactic acid esters*. The aim of this work is the valorization of whey permeate by means of the production of lactic acid and valuable

derivatives, such as lactic acid esters. For that purpose, three tasks are being carried out: i. Improvement of the continuous production of lactic acid by fermentation by means of lactose prehydrolysis. ii. Recovery of lactic acid from broth by membrane-assisted extraction (pertraction). iii. Production of lactic acid esters by combined reaction-separation processes.
In order to carry out tasks i and iii, two systems involving enzymatic membrane reactors have been constructed. Once the lactic acid is recovered and purified from the fermentation broth, it can be used as raw material in the production of a number of valuable chemicals, i.e., esters (which then can be used as solvents from renewable resources, or as intermediate products in the manufacture of, e.g., biodegradable polymers). The esterification reaction is usually carried out in a reactive distillation column, catalyzed by either mineral acids or ion-exchange resins. This reaction could also take place in an enzymatic membrane reactor in organic phase, by immobilizing a lipase capable of catalyzing the conversion.

4. Removal of volatile organic compounds (VOC´s) by pervaporation

The purpose of this work is to optimize the operating performance of a pervaporation process for the removal of VOC's from aqueous streams. Toluene-water and trichlorethylene-water systems have been studied using a polydimethylsiloxane membrane.Feed composition has been varied from toluene and trichlorethylene solubilities down to 100 ppm.

Catalytic treatment of volatile emissions from coke ovens

Coke ovens are a major source of atmospheric pollution. Their emissions are rich in methane (up to 12000 ppm), different VOC’s (such as benzene or ethylene), ammonia, hydrogen sulphide, and sulfur and nitrogen oxides. The abatement of VOC’s and CH_4 in these emissions is especially difficult, because of the presence of the above-mentioned inorganic compounds.

The scope of this project is the selection of catalysts to carry out the catalytic incineration of these emissions to work in this environment. The main conclusion of these experiments were the higher activity of Pd catalysts (although their resistance to poisoning is not very high) and the predominant role of the sulphur compounds in the deactivation of the catalyst.

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CLEANER CHEMICAL PROCESSES BY USING PINCH ANALYSIS AND MATHEMATICAL PROGRAMMING

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Energy and material recycling is required to save the natural resources and protect the nature. Pinch analysis is nowadays a practical tool for designing heat exchanger networks (HEN) in chemical and process industries. Yet, heat integration alone is not sufficient for process integration. The largest savings are achieved when simultaneously integrating and optimizing heat and mass flows. Mathematical programming is increasingly used to optimize process structure and its parameters, both in continuous and batch operations. Two examples of the cleaner production program in Slovenia will be shown:

Sulfuric acid production from sulfur has been optimized simultaneously using rigorous models and direct search optimization. The additional profit may be increased by 2.8 MEUR/a, mainly because of higher temperature driving forces yielding a reduced investment in HEN. The profit comes mostly from the 13.3 MW increased steam production without using any fuel!

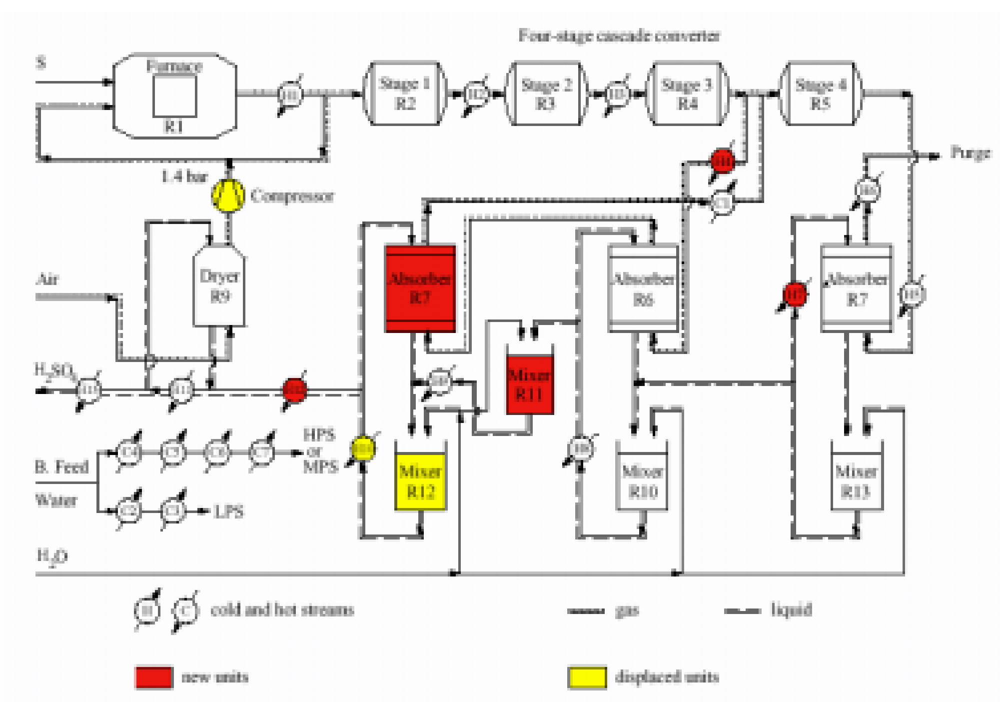

Figure 1. Flowsheet of the modified sulfuric acid process

An existing, low pressure Lurgi methanol process was to be retrofitted and optimized. A three-step approach was applied:

- Generation of a superstructure by pinch analysis
- Formulation of a mathematical model
- Optimization using process simulator and mathematical programming

Simultaneous optimization of heat, conversion and mass flow rates has saved 5.26 MEUR/a, *i.e.* 6.7 % of the total annual income, with the payback time of less than 1 month. 97 % of the savings come from the additional methanol production. 2.4 MW of additional steam can be produced using 0.5 MW of additional fuel only and 17 % of cooling water is saved.

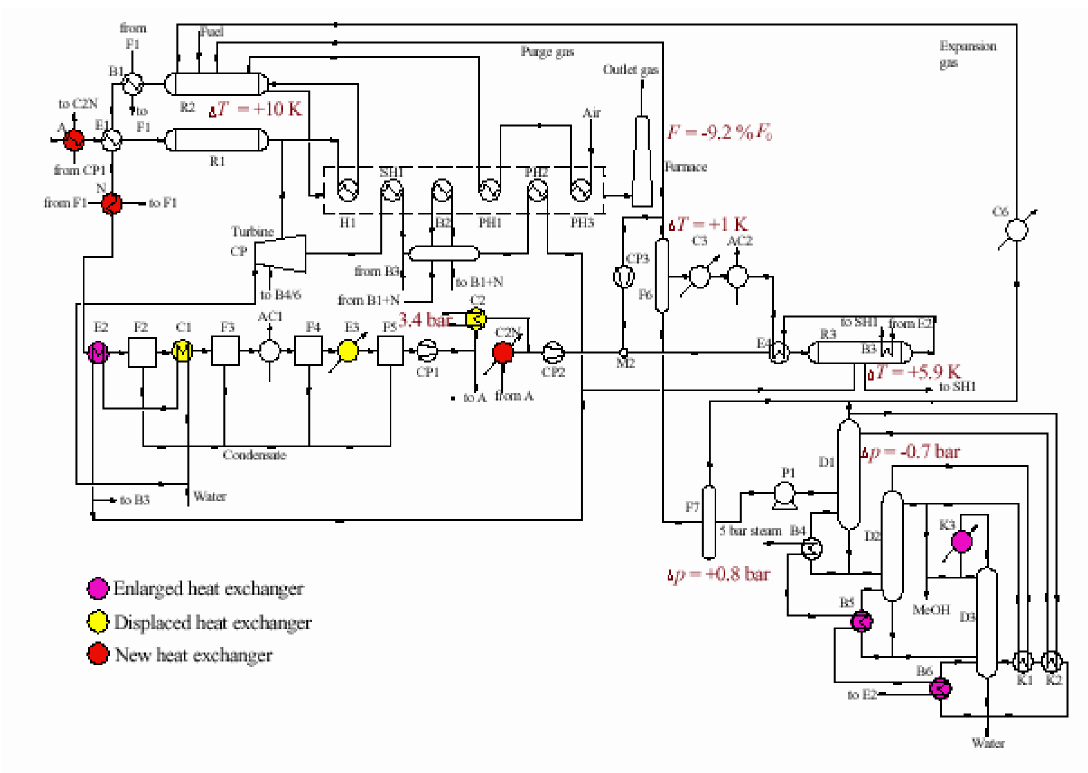

Figure 2. Methanol process flowsheet after heat integration

POLLUTION PREVENTION IN ROMANIA - OPTIMISTIC PERSPECTIVE

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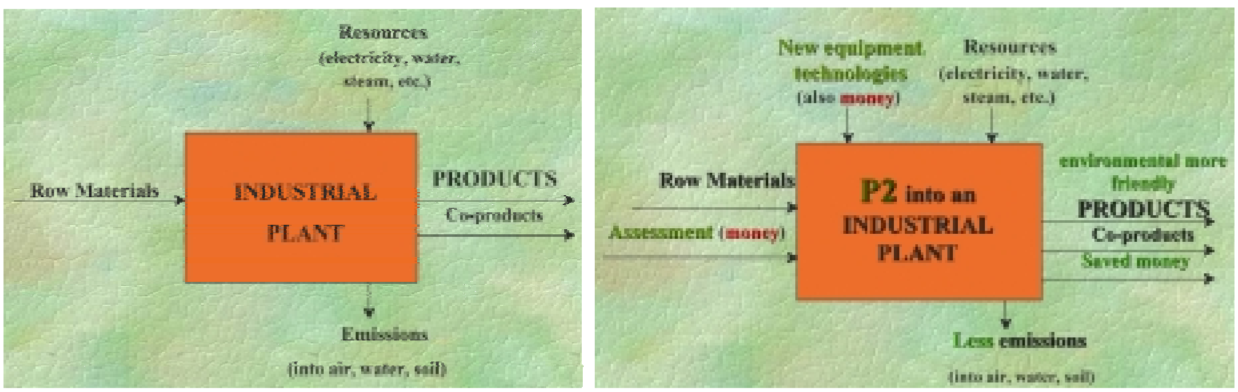
As many other East European countries, Romania is crossing a difficult transition period. In political terms, it means passing from communist political system to the democratic one, and in economical terms from a strong centralized to the free market economy. In the first years of transition, many industrial plants in Romania strongly diminished their production, this reduction ranging from 30 up to 80 %. After a long period of stagnation at this very low level of production, the surviving plants will increase (most of them slowly) their production in the next years. Like other East European countries, Romania has to help its viable industrial plants to increase their production, or it will remain longer as undeveloped country.



(A) (B)

Figure 1. LCA scheme (A) and pollution prevention (B) for an industrial process

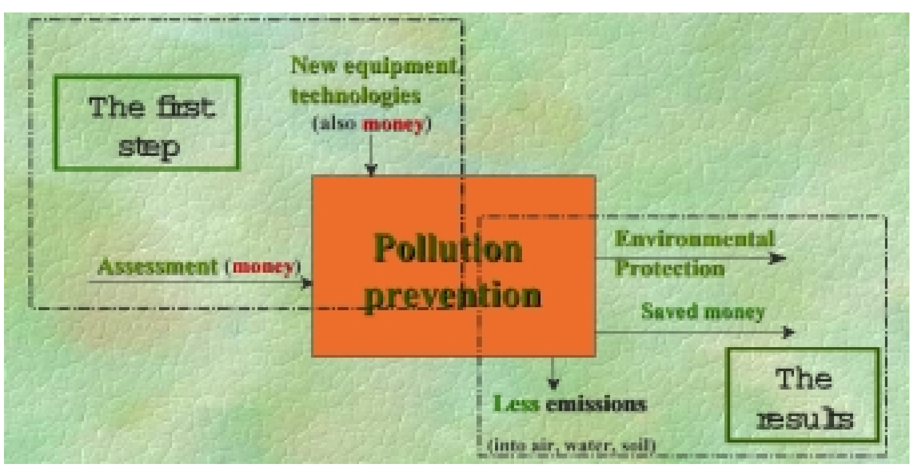


Figure 2. LCA scheme for pollution prevention

From ecological point of view, the reduction of industrial production level lead to smaller number of pollution sources and smaller quantities of emitted pollutants. The transition period has represented for environment in Romanian a break in its fight with industrial pollution. This truce will be ended soon, and the only help for environment will remain pollution prevention (P 2). A Life Cycle Assessment scheme for any industrial plant reveal that pollution prevention measures applied in the plant will lead at reduction of pollutants emissions, and also to some saved money.

Optimistic perspective of pollution prevention in Romania is derived by the fact that it is the only way for industrial development and Romania can not remain an undeveloped country. The paper presents some individual actions for P 2 application in Romanian industry.

CLEANER TECHNOLOGIES AND INDUSTRIAL ECOLOGY

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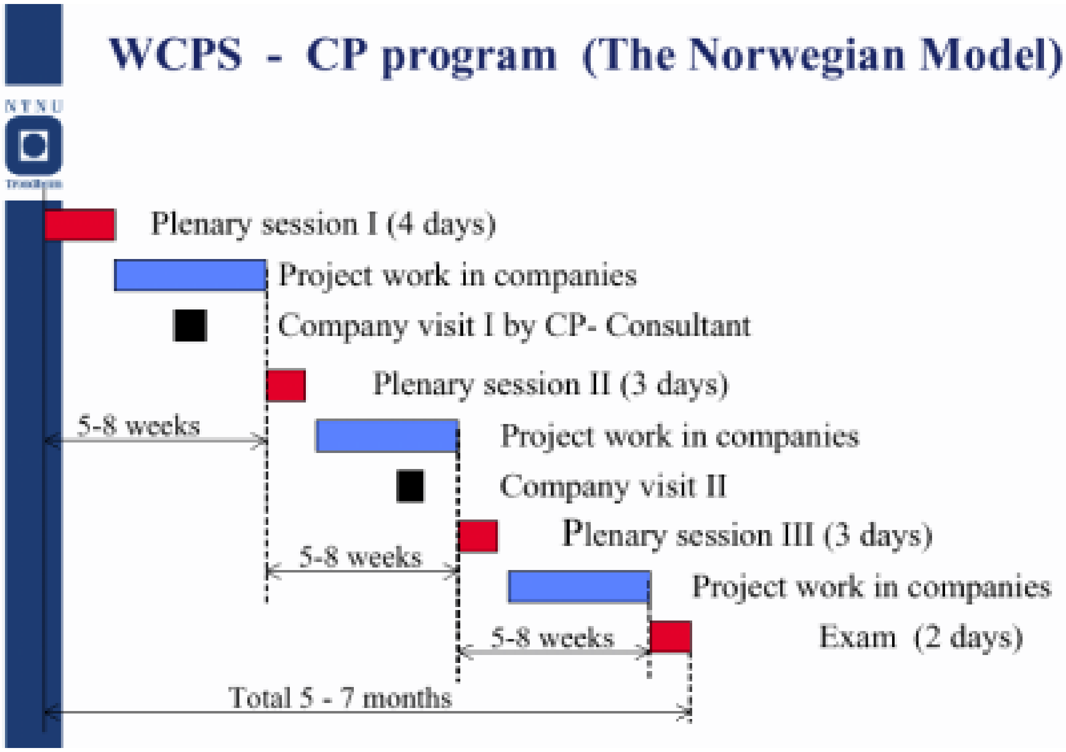
The presentation will give an overview of research projects within the area of Industrial Ecology and Cleaner Production at the Norwegian University of Science and Technology, NTNU. UNEP has defined Cleaner Production as “the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase eco-efficiency and reduce risks to humans and the environment.” In the presentation I will exemplify this by case-studies from Norwegian industry.

World Cleaner Production Society (WCPS) is a Norwegian based group of consultants working in a number of countries on CP programs mostly funded by NORAD and the Norwegian Ministry of Foreign Affairs. The presentation will give an overview of such programs and how they are performed in different countries all over the world. Our first CP program was initiated in Poland from 1990, and later on other CEE countries. Based on experiences from Poland, Czech and Slovak Republic, a guide on implementation of CP was developed (“The Best Practices Guide for Cleaner Production Programs in Central and Eastern Europe”). The approach is very practical with applying principles like in plant training, training by doing and train the trainers. Later on CP Programs have been implemented according to the “Best Practices Guide” in north west Russia, Lithuania, Tunisia, Zambia, Indonesia, China (Beijing and Hunan). For the time being programs are running in Russia, Tanzania and Pakistan. Some experiences and results form these programs will be presented.



THE ROLE OF ORGANISATIONAL FACTORS IN THE IMPLEMENTATION OF CLEANER PRODUCTION MEASURES

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An empirical research undertaken at the Hungarian Cleaner Production Center at the Budapest University of Economic Sciences concentrated on the organizational factors of energy related cleaner production measures at several significant Hungarian companies. The underlying objective of the research was to analyze this special set of barriers to preventive environmental actions which often impede the implementation of cost effective instruments at the company level. As a result of the research, a number of these organizational barriers have been identified at eight enterprises of the Hungarian industry and recommendations have been developed to overcome such difficulties.

The international literature concerning the improvement potential of existing energy efficiency levels refers to the so called "energy efficiency gap" as the energy efficiency potential which is not exploited in practice and indicates the difference between the economically optimal and practically implemented levels of energy efficiency measures. In other words, the energy efficiency gap covers the total amount of so called "no-regret options" (options which are feasible to implement purely on a financial basis) which are not utilised by individual producers or by state organizations.

Several reasons for the existence of the energy efficiency gap have been identified during the last decade which focus on the following question: why does the practical implementation of energy efficiency measures lag far behind potential energy efficiency levels suggested by both theoretical results and implemented practical solutions (for a detailed discussion on the energy efficiency gap see for example the special edition of Energy Policy [1]).

Similar questions have been the focal points of discussions between cleaner production experts at the national and international levels during the last couple of years: why are cleaner production measures not implemented on a much wider scale and why is it so hard to convince company representatives of the advantages of preventive environmental measures.

Different explanations have been developed to answer these questions concentrating on market barriers, the risk and uncertainty of preventive environmental actions and - lately - some attention has been paid to the organizational factors determining the level of preventive environmental measures (see for example [2] and [3]).

For the purposes of this study organizational factors will be defined as those factors characteristic to an individual enterprise which have an influence on the level of its preventive environmental actions. Organizational factors include the size, organizational form and industry of a company, the available infrastructure (the state and type of equipment used), and human behavioral patterns, etc.

The presentation will focus on the organizational factors of preventive environmental measures specific to a set of eight leading Hungarian companies. Results prove that the implementation of such measures requires far more than the availability of financial resources and the identification of cleaner production options, but one should not forget about the built-in capital already used and other infrastructural barriers; the motivation and commitment of employees at all levels of the organization; the process of decision making within the organization; organizational learning and issues relating to organizational culture.

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NATIONAL PROGRAM FOR CLEANER PRODUCTION

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The preventive strategy for environment conservation assessing the impacts of man onto the environment as a whole – in an integrated manner – and does not support pollution transferring from one component of environment into another one, provides options for choosing method for achieving the set goals in the environment protection with the use of preventive methods. Cleaner production is one of the instruments supporting application of preventive protection of the environment and contributes to sustainable development in the Czech Republic.

The worldwide tendency in environment conservation aiming at the use of preventive instruments in protection of the environment, many a time confirmed high efficiency of the cleaner production method for industrial plants and services, these were the main reasons why the Czech government approved in its decree no. 165 of Feb 9, 2000 the National Program of Cleaner Production to support such activities and greater exercising thereof in all branches of the national economy. First information assessing the benefits of cleaner production method were submitted to the government in March 2001 and adopted by the government in April 2001.

In the course of cleaner production implementation in the CR, several very positive results of this method were achieved in the environmental effectiveness terms which took effect e.g. in decrease in the amount and toxicity of waste (solid, liquid and gaseous) directly with their sources, more effective use of energies, raw materials and materials was achieved resulting in savings with the plants. This confirmed the economic benefits of this method.

Application of such method led many times to decrease in capacity of the end technologies (waste treatment plants, separators and other devices limiting the pollution output into the environment); in some cases the cleaner production even caused that installation of such end technologies was unnecessary. This method concerns also the company management and organization where saving of labor was noticed several times.

Introduction of cleaner production in companies led simultaneously to continuous decrease in adverse impacts of production onto the environment. Undoubtedly, another important aspect is that the introduction of cleaner production decreases not only the impacts onto the environment, but also on human health and safety.

Based on its achievements in enforcing and implementation of cleaner production within the National Program for Cleaner Production, the Czech Republic was rated positively at the 6th worldwide seminar on cleaner production organized by UNEP and Canadian government in Montreal in 2000. Based on an agreement between the Minister of Environment of the CR, Mr. Kužvart, and the undersecretary of the UN and the executive director of the UNEP, Mr. Klaus

Töpfer, the 7th seminary on cleaner production will take place under the auspices of UNEP in Praha in 2002.

CYCLE OF REUSING INDUSTRIAL DUSTS FOR WASTEWATER TREATMENT AND CONSTRUCTION

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Among the pollutants which are released into the natural environment there are chemical compounds containing heavy metals. A variety of physico-chemical techniques are employed for removal of heavy metals from industrial wastewater. Among these techniques, adsorption and ion exchange methods are granted a particular interest. One of them is based on the utilization of waste industrial dusts.

Fly ash produced by coal-fired power plants is utilized as a raw material for the production of foamed cellular concrete blocks (autoclaved aerated concrete) using the foam-gas-silicate technology (FGS). The metal processing industry produces a large amount of iron containing dusts. An appropriate composition of the concrete mixture and the iron rich dust may produce a highly efficient material which can uptake heavy metals from industrial wastewater.

The Pollution Prevention Center at the Technical University of Lódz has developed an adsorbent-like material which is a type of cellular concrete with built-in active centers. The adsorbent is made of waste materials, thereby it is cheap. The effectiveness of the material work is very high. After a relatively short time, 90 % of metal is removed from the standard aqueous solution of a salt of a single metal. The usefulness of the material has been corroborated during treatment process of wastewater created in electroplating facility. In the cleaning process, the treated stream goes through a layer of the material (fixed bed) placed in a cylindrical apparatus. The bed of 1 m^3 volume has an ability to uptake 25 to 50 kg of metal from a solution, which means cleaning capacity ranging from 2.5 to 5 x 10^3 m^3 of waste water containing 10 mg/m^3 of metals. The heavy metals comprised in the material after being used up are no longer in ionic form. The form of the trapped metals is resistant to being washed away from the concrete matrix, thus the exploited adsorbent may be used again as an aggregate for production of lightweight building blocks (non-fines concrete) or in other construction materials.

CASE STUDIES OF INDUSTRIAL WASTEWATER TREATMENT IN CONSTRUCTED WETLANDS

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Potential of constructed wetlands systems for the treatment of industrial wastewater will be presented.

Constructed wetlands combine the benefit of an aerobic biological filter with the physico-chemical properties of the soil matrix and of the vegetation ryzosphere due, mostly, to the large dynamic surface area that it supplies to the adhesion of microorganisms enabling oxygen and nutrients transfer.

Helophytes such as *Phragmites sp.*, common reed, is one of the most abundant plant in the Portuguese river banks being the one selected for all the cases shown.

Reed beds have been built and operated since 94 at large industrial scale aiming the removal of nitroaromatic compounds and of large quantities of nitrates. A sandy-clay vertical and a light expanded clay aggregates horizontal, subsurface flow systems were used for organics and inorganics removal, respectively. The high removal efficiency obtained in each case enables the possibility of the recirculation of the treated water to the process.

Landfill leachate and wastewater from the MSW transfer station is also being treated in a closed reed bed system, except for very high rainfall situations, with success.

Agroindustrial effluents namely those with a very high impact in all the Mediterranean region, like olive mill wastewater are being applied to reed beds which eliminates the toxicity associated with polyphenolic compounds and simultaneously reduces the organic matter content.

Design strategy from laboratory scale to full scale will be discussed.

CLEANER PRODUCTION AND PRODUCTS IN LITHUANIA

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We have to agree, that Cleaner Production (CP) should attack the possibilities for making improvements in use of energy, the use of raw materials, the reuse or recycling of waste energy and materials. CP has several clear advantages over pollution control. Any pollutant that reaches the end of the pipe represents a loss of raw material Since CP seeks to minimize the amount of material that suffers this fate, it is good way of conserving natural resources.

At the same time there are also difficulties inherent in the cleaner production concept. From the perspective of the authorities, it is far more problematic to legislate and monitor than conventional pollution control. CP is not usually accomplished simply by placing a new equipment immediately ahead of a discharge point. Identifying good CP solutions often requires a high degree of technical expertise and creativity, and ideas are not always directly transferable, even between similar industrial facilities.

When looking to international literature on case studies for the implementation of CP in industry, there is an overwhelming number of good housekeeping examples reported. Sometimes one gets the impression that CP in practice is mostly good housekeeping oriented. This is, however according our experience not the case, but in its beginning CP naturally tends to focus on the easiest achievable option-‘picking the lowest hanging fruits”

Normally, good results were achieved by use of conventional mass balances for energy and given materials. Mass balances should be performed in practice much more than they are today, both to have an idea of sources and losses in daily operation of the production processes, and particularly before larger investments are introduced. Mass balance equations together with objective function, limitations, initial and final conditions can serve for the advanced process control and process optimization.

Cleaner production approach depends on overall process designs that are intrinsically environmentally friendly. This calls for the philosophy of process design that recognizes the unity of the whole process called as process integration. A systematic approach to industrial process designs fundamentally changing the way in which process design and retrofit activities are carried out. This method do not, in general, attempt to invent new types of equipment or unit operations, rather, they focus on ensuring that existing process technologies are selected and interconnected in the most effective ways. Typically the procedures start with an overview of the process as a whole, rather than focusing on individual unit operations or pieces of equipment. In this way an optimal structure can be developed for the overall plant, with individual items of equipment being fit into this structure.

According the original UNEP definition Cleaner Production is the conceptual and procedural approach to production that demands that all phases of the life cycle of a product or of a process should be addressed with the objective of prevention or the minimization of short and long term risks to humans and the environment. Cleaner Production processes means activities aiming to improve the CP aspects of production process design and operation. Such measures normally include operational changes and technical improvements in (parts of) the industrial production process, in order to achieve waste prevention or minimization, or the reduction of energy and raw materials input. In practice, very many such initiatives aim to close the production loops of a process, which often may be the first step to achieve waste minimization.

Cleaner Production Product means activities to improve the environmental qualities of products, based on life cycle or “cradle-to-grave” approach. Such measures usually involve environmental impact assessment in the life cycle oriented production, use and final destruction of the products including their input components.

General findings and considerations:

- Industry still does not consider Cleaner Production initiatives as an option for improving productivity parallel to an increased protection of the environment. End-of-pipe solution is commonly applied if environmental demands are to be met by converting pollution from one form to the another

- Investments in Cleaner Production increase the profitability for industry by increasing productivity and product quality, cutting the cost for raw materials and energy, reducing the need for large investments in pollution abatement equipment

- It is important to integrate Cleaner Production efforts and general development and innovation issues. NGOs, motivated industrial sectors and labor unions must be more involved in the discussions about the outcome and objectives for Cleaner Production, and the principles in the national legislation could be launched in order to promote Cleaner Production including more strict standards

- There is an urgent need to integrate Cleaner Production into EMS. Firstly, Cleaner Production is not a continual and normal practice for industry. Secondly, Environmental Management Systems are no guarantee that Cleaner Production will be applied or even an environmental performance above regulatory requirements will be obtained. EMS focuses on quality and strengths of procedures, and not the actual outcome of these procedures regarding pollution abatement and improved resource productivity

- Environmental reporting and data in management context could be as an opportunity to promote environmental improvements and cleaner production. Data logging in Production Management Information Systems to control budget compliance could embrace the logging of essential environmental data to control environmental targets. A link between management accounting and environmental management could be created based on key performance indicators, that encompass environmental targets, such as decrease in outlets, degree of compliance, and number of spillage

Cleaner Production requires the involvement and support of managers and workers at all levels within the organization. Integrated, preventative environmental options have to be based on the motivation of such people, which is a key reason for a shift towards consensus-seeking regulation strategies. Therefore, extremely important for the successful CP implementation is an integration of technical, managerial and financial means and possibilities. The growing acceptance of new terms like “sustainable industries” and “industrial ecology” indicates that one is looking in the right direction.

As it was mentioned before, system’s approach should be used to cleaner production assessment. In order to be able to identify waste prevention activities, the field of interest has to be defined as clearly as possible and a method has to be used which is likely to produce the desired answers to the question.

Professor Jurgis Staniskis, APINI, Kaunas University of Technology, giving a presentation on Cleaner Production and Products in Lithuania

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Running now on its third year, the center has progressed on both method development and Cleaner Production implementation in industry. This pilot project up-date will report the progress within textile industry, moulded paper pulp industry and industrial laundering as well as within method development.

Textile industry. A number of process modifications were identified within the polyester yarn dyehouse among which were substantial reductions on resource consumption and effluents from CIP (Cleaning-in-Place) processes. A liquor displacement insert (a so-called "dummy") for use during the frequent CIP of the dyeing machines was developed and implemented successfully reducing water, energy and chemical consumption and emission by more than 50%. Moreover, a spray rinse system for CIP'ing the chemical-addition tanks was developed and implemented leading to even greater relative savings. Both systems have simple pay-back periods of a few months. Energy and mass integration studies were carried out identifying large potentials for heat exchange and direct water recycle – up to around 50% savings. The direct water recycle options were successfully tested in lab-scale and subsequently in full scale for several weeks documenting the potentials. The feasibility of counter current evaporation and membrane technology was investigated for upgrading the remaining water for reuse. Membrane technology was found to be the most promising alternative, and both nano-filtration and reverse osmosis were tested in lab-scale and pilot scale. At present, large pilot scale tests are conducted and some problems with pre-filtration of various suspended solids are experienced.

Textile laundering. Successful operation of full scale direct reuse of around 40% of the water has been achieved at a batch workwear laundry over a year. Moreover, biological treatment of the remaining water has been established and operated documenting that its is possible to up-grade and reuse the water in the wash process by this technique. The hygienic quality of the water most be controlled and further improved, though. Ultra-filtration of the wash water was tested in pilot scale showing good performance of the ultra-filtration, but problems with reusing the permeate in recipes comprising wash of slaughterhouse textiles, probably due to presence and/or formation of volatile fatty acids lowering the alkalinity of the permeate unacceptably. Membrane Bio-Reactor (MBR) technology was successfully tested in pilot scale, and full scale implementation is being considered for further testing at one laundry.

Moulded paper pulp industry. A number of water recycle scenarios were simulated by computer modeling and by lab-scale construction and simulation of the systems. The water quality of the systems in the various scenarios was thereby simulated and tested, identifying thus the physical, chemical and biological quality of the recycled water in the scenarios, including the growth potential for microbial growth. It was found that the easily degradable organic matter was released from the raw material immediately after pulping. Moreover, it was found that a substantial part of the degradable organic matter was added via the ancillary substances. Nitrogen has proven to be limiting to growth, and nitrogen is added partly with the raw material partly with chemicals, mainly with the biocides. It seems, thus, that the biocides to some extent carry within them the cause of the need for them. Alternatives to using biocides, i.e. using dispersing agents to prevent the formation of biofilm on the inner walls of the system, was successfully tested in full scale. Moreover, it turned out that emptying and cleaning the system every two weeks is enough to prevent growth, and that such a system can be operated with no use of biocides what-so-ever.

Method development. In a US-Danish co-operation, simple and operational methods for process integration were developed applicable for both batch and continuous processes. The methods have been prepared and submitted for publication in Journal of Clean Products and Processes. Various softwares for computer modeling and simulation are under investigation and testing. A technology database is under preparation.

Newsletter. The progress and results achieved in the center is briefly reported in a newsletter available on the center web-site: www.cevi.org.

AGRIFOOD INDUSTRY IN BULGARIA

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The development of cleaner food production industry in Bulgaria is a part of the National Action Plan on the Environment – Health. By this Action Plan Bulgaria integrates to the policy and actions of the European Union for strengthening human health and sustainable development of the countries.

The Bulgarian legislative and sub-legislative framework related to the safety food is in a process of harmonization with the EU Directives, recommendations of the Food Code standards, and ISO systems. Actualized Rules on hygiene requirements to the food additives have been adopted and they are approximated to the EU directives in this field. Act on Foods had been adopted in 1999. Programs are developing in different regions of the country for introducing the EU hygiene standards and requirements on the food processing and reprocessing.

The measures mentioned above give us a possibility for development of the food industry at a European level. Food and food processing policy is a part of the National Agricultural policy. Among the agricultural priorities the following concern food and food processing:

- *Improvement of the national legislative framework in the field of safety food and its harmonisation with the EU legislation.* This includes development of acts, legislative norms and standards;

- *Strengthening and improving monitoring system on food control.* This includes control on food agricultural products, their processing and sell; monitoring on food safety.

The training priority in the Action plan is to provide conditions for training high-quality specialists in the field of environment – health, able to ensure its effective management and optimization.

Dr. Stefka Tepavitcharova, Bulgarian Academy of Sciences

THE STATE OF PLAY OF THE IPPC/96/61/EC DIRECTIVE: THE CASE OF FOOD INDUSTRIES WITH SPECIAL REFERENCE TO GREECE

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Even though, the last decades significant improvements have been achieved in industry regarding several major polluting substances, industrial production processes still account for a considerable share of the overall pollution in Europe. So, the EU set out a set of common rules on permitting for industrial installations, the so-called *Integrated Pollution Prevention and Control Directive* (IPPC 96/61/EC).

In essence, the IPPC Directive is about *minimizing pollution* from various point sources throughout the European Union. All installations covered by *Annex I* of the Directive are required to obtain an authorization (permit) from the authorities in the EU countries. Unless they have a permit, they are not allowed to operate. The permits must be based on the concept of Best Available Techniques (or BAT), which is defined in *Article 2* of the Directive. Since the permits must be based on BAT, the licensing authorities need some assistance to find out which techniques are BAT. *Annex IV* of the Directive contains considerations to be taken into account when determining BAT. Furthermore, the European Commission organizes an Information Exchange Forum (IEF), which consists of representatives from Member States, industry and environmental non-governmental organizations. This work is coordinated by the European IPPC Bureau and it has been divided into some 30 sectors. Each sector of work is addressed by a specific Technical Working Group (TWG) established for the duration of the work with the purpose to produce (usually within two years) a so-called BREF (BAT reference document) which will assist the licensing authorities, in issuing operating permits. All BREFs will be completed by the end of 2004.

Dr. George P. Gallios, Aristotle University of Thessaloniki

PILOT PROJECTS UPDATES

TOOLS FOR POLLUTION PREVENTION

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The elements of this project, Tools for Pollution Prevention, was provided in earlier reports of this Pilot Project, specifically in the 1999 Annual Report (NATO CCMS Report Number 238). Essentially two types of technical tools were recognized to be useful for designing cleaner products and processes. The first kind, called analytical (or software) tools are used for analyzing, assessing, predicting, and designing product and process systems. The second kind, called process (or hardware) tools are derived from science-based knowledge that is mostly derived from experimental investigation. Green chemistry and syntheses, separation methods are examples of the second kind of tools. This project is only concerned with the analytical tools. Here is status of the tools being developed at the National Risk management Research Laboratory, USEPA, Cincinnati.

- Pollution prevention progress (P2P): The Mark III version of P2P, which is Windows-based, is ready. P2P allows determination of progress made in a change purposely made, such as using a substitute, or a different process of manufacture.

- Waste Reduction (WAR) algorithm: This algorithm, used in conjunction with a commercial process simulator, allows quantification of pollution emission from a manufacturing process. The algorithm can then be used to modify the process for improving its environmental performance. WAR has been commercially available with the simulator, Chemcad, marketed by Chemstation. It has also been included in several academic simulators, and has been in use in the Philippines for reducing pollution from several processes. A commercial collaborator is making a stand-alone version of WAR. Upgrades for a network of processes are being researched now.

- Program for Assisting the Replacement of Industrial Solvents (PARIS II): PARIS II, a solvent design software, developed by researchers at EPA, was commercialized in 2000, and is available from TDS, Inc of New York, New York.

- Tools for the Reduction and Assessment of Chemical Impacts (TRACI): TRACI is now ready for testing. TRACI was developed to allow quantification of adverse environmental impacts of chemicals such as those that are found in products.

- A new tool recently developed correlates chemical toxicity, aquatic and biological, with structure using the group contribution method. This tool will allow prediction of toxicity of chemicals for which data do not exist.

- LCAccess is an LCA data portal recently launched on the EPA website. This portal allows access to available LCA data through hyperlinks. It is also a good primer for LCA.

Various other tools in this analytical tool category are being developed elsewhere. Of particular mention is the use of the mass exchange network (MEN) analysis, which has been pioneered by Manousiothakis and El-Halwagy, and has been successfully used in reducing water use in plants by various workers in the field.

Subhas K. Sikdar, U. S. EPA, Pilot Study Director

ENVIRONMENTAL IMPACTS OF HC EMISSIONS IN LIFE CYCLE ANALYSIS OF GASOLINE BLENDING OPTIONS

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Changes in gasoline specifications worldwide affect demand for all major gasoline-blending components. The purpose of this study is to compare different gasoline formulations based on the accounting of the environmental impacts due to hydrocarbon emissions during the gasoline production and marketing. Gasoline blending streams used to meet all the specifications are: reformate, alkylate, cracked gasoline and butane. The two most important variables to consider in the gasoline blending are the research octane number (RON) and the Reid vapour pressure (RVP) which are subject to technical and environmental constraints. This study considers two gasoline octane grades, the 95 and the 98 RON. Among these two gasoline grades several formulations will be compared, i.e., with a different content of butane, reformate, alkylate and cracked gasoline. In doing the several gasoline formulations it is important to meet the RVP requirements defined by the EU Fuels Directive. This study accounts the gasoline losses due to evaporation and leaks, using existing methods in the literature, and evaluates the potential environmental impacts, using the Waste Reduction (WAR) algorithm. It includes eight impact categories: human toxicity by ingestion and by dermal/inhalation routes, terrestrial toxicity, aquatic toxicity, photochemical oxidation, acidification, global warming and ozone depletion. This analysis includes the several steps in the gasoline life cycle: the manufacture, storage, loading in tank trucks, loading in tankers or barges, transit losses during the transportation of gasoline to service stations, storage at service stations and vehicles refuelling. This study also considers the variation of the operation conditions of the reforming process, to adjust yield versus octane number, using process simulation. The calculated values are good estimates of the real process allowing different aspects to be easily analyzed. Several conclusions came from this study, concerning an environmental evaluation of the different gasoline options and formulations and about the operation conditions that should be used in the reforming process in order to met the gasoline specifications.

PILOT STUDY WEB SITE

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Since the third meeting of the NATO CCMS Pilot Study on Clean Products and Processes in Copenhagen, Denmark, in May 2000, a pilot study web site has been established. As discussed in Copenhagen, the purpose of the web site is to enhance communication within the pilot study and to external stakeholders and customers. The purpose of this pilot project update is to propose specific applications for the web site and to solicit suggestions from the pilot study delegates.

At this point in time, the web page is designed to first describe the pilot study and provide on-line reports of the activities of the pilot study. In addition, each participating nation is identified with appropriate information and links to organizational web sites.

Proposals to be discussed will be to provide interim pilot project status reports on the site, to develop an international clean products and processes portal site, and to request that each nation become actively involved in keeping the pilot study web site updated by working closely with U.S. EPA.

Daniel J. Murray, Jr., U. S. EPA, Pilot Study Co-Director

POLICY STATEMENT ON DEVELOPING GOODS AND SERVICES WHICH MEET PEOPLE'S NEEDS BUT INVOLVE THE USE OF FEWER NATURAL RESOURCES IN MOLDOVA

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The methods of investment distribution in the centralized planned economy in the past in Moldova has generally subjective character with rather political motivations than economic ones, especially in environment protection area. But however, the organization and management of interactions between modern society and environment has the goal of current consumption needs satisfaction, not endangering the future generations needs and aspirations satisfaction.

To implement this policy, government needs adequate instruments. One of them have being meeting consumer needs and aspirations: how well goods and services meet human needs and raise living standards and their use makes efficient use of resources.

Taking into account the reality, the values involved in the economic process in Moldova at the moment (specific for all countries in transition) need a specific functional priority, according to the necessities of natural resources restoration, their use in an adequate regime of permanent regeneration and ecologic balance conservation. Natural potential lies at the basis of production and other economic processes. At the moment in my country is widespread disorientation among companies often leading them to make decisions, which are incorrect from the technical/economic/environmental viewpoint and investments, which are disproportionate.

NEW PROCESSES AND MATERIALS FOR ENVIRONMENTALLY BENIGN SEMICONDUCTOR MANUFACTURING

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The rapid growth of semiconductor industry presents special environmental obstacles and technology issues. These challenges are beginning to have significant impact on both the development of new processes and the application of new materials for modern IC manufacturing. In this presentation, some of the technical issues and potential solutions will be discussed and the R&D efforts for developing a new generation of environmentally benign manufacturing will be reviewed. In particular, examples from the on-going research at the NSF/SRC Engineering Research Center (a consortium of 7 universities) on this topic will be discussed. The examples will cover research progress and technology needs in selected areas including: surface preparation/wafer cleaning, new dielectric materials (high-k and low-k), gaseous emissions particularly of global warming compounds in lithography and plasma etching, environmental bottlenecks in chemical mechanical planarization (CMP), and finally, environmental drivers for process integration in patterning and deposition of dielectrics in copper/low-k dielectric systems.

Professor Farhang Shadman, University of Arizona

PILOT PROJECT ON EVALUATION OF CLEAN PRODUCTS AND PROCESSES IN MEMBER COUNTRIES

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The concept of sustainable development universally accepted as the means of protecting the environment for all mankind, demands that future manufacturing technologies must be cleaner, yet economically sound. With continued industrialization and improving standard of living among nations, and with increasing globalization of markets and means of production, all nations by and large are facing similar environmental challenges in the manufacturing sectors. We established this pilot on Clean Products and Processes to create an international forum where current trends, developments, and know-how in cleaner technologies, and in tools for measuring cleanness can be discussed, debated, and shared. We hope that this pilot, through its annual meetings, will help stimulate productive interactions among experts, with the expected benefits of effective technology transfer.

A specific part of this pilot study was developed to integrate all the pilot project country members in sharing cleaner production and products information. The members at the annual meetings have helped direct the information-sharing activities through selection of specific industry categories for review. In the 1999/2000 time period, the countries developed responses to information for their specific country on

- the history of the overall program for cleaner production
- textile industry sector

These results are found in detail as a part of the Proceedings from the Copenhagen NATO/CCMS meeting.

Current program

The member country representatives selected for the 2000/2001 time period the following:

- Metal Plating/Coating Sector
- Food and Agriculture

In general there are questions on the historical development. Then there is a characterization of each sector. Finally, to help augment the network of those working with each sector to foster pollution prevention, technical experts are identified.

Questionnaires:

METAL PLATING/COATING INDUSTRY SECTORS
NATO CLEAN PRODUCTS AND PROCESSING PROJECT

Country

For this questionnaire, on the Metal Plating/Coating industry, please respond only for the medium size or larger part of this industry sector.

1. As of January 2001, for how many years has the industry in your country's Metal Plating/ Coating Sector been considering and implementing cleaner production changes (in other words, about how old are the cleaner production programs for Metal Plating/Coating sectors in your country)?
2. Is the Metal Plating/Coating sector considered in the top 5 industrial sectors in your country?
3. In the Metal Plating/Coating industry, are there a large % of small facilities (less than 5-10 people)?
4. Please list the 3-4 of the most commercially attractive cleaner production changes used in the Metal Plating/Coating industry in your country. Include one or two sentences on each of these 3-4 changes, if such information is available.
5. What two new ideas for Metal Plating/Coating cleaner production seem to be exciting or of significant value in your country?
6. Please list 2-3 industrial or technical experts in your country who you believe are the most knowledgeable in the Metal Plating/Coating cleaner production field. List the full mailing address, telephone, and email.

PPRCNATOMETALPLATING/COATINGQUESTIONAIRE2001

FOOD AND AGRICULTURAL PROCESSING INDUSTRY SECTORS
NATO CLEAN PRODUCTS AND PROCESSING PROJECT

Country

1. As of January 2001, for how many years has the Food and Agricultural Processing industry in your country been considering and implementing cleaner production changes (in other words, about how old are the cleaner production programs for food and agricultural processing sectors in your country)?
2. Is the Food and Agricultural Processing sector considered in the top 5 industrial sectors in your country?
3. Please list the 3-4 of the most commercially attractive cleaner production changes used in the food and agricultural processing industry in your country. Include one or two sentences on each of these 3-4 changes, if such information is available.
4. What two new ideas for food and agricultural processing cleaner production seem to be exciting or of significant value in your country?
5. Please list 2-3 industrial or technical experts in your country who you believe are the most knowledgeable in the food and agricultural processing cleaner production field. List the full mailing address, telephone, and email.

PPRCNATOFOODANDAGRICQUESTIONAIRE2001

INVITED PRESENTATIONS

HOW GREEN ARE GREEN PLASTICS?

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Much has been made of the environmental shortcomings of conventional fossil oil based polymers such as Polyethylene, Polypropylene and Polystyrene. In contrast, biodegradable plastics that are made from renewable resources have been viewed as a sustainable route to plastic manufacturing and as such have been regarded as an environmentally friendly alternative.

However, very often an environmental burden is caused by the manufacture of a given product and only to a minor extent by its ultimate use. Hence a "cradle to grave" analysis, which incorporates manufacturing practices, resource utilization, land use and overall emissions becomes the benchmark for assessing the environmental impact of a given product.

We have conducted two life cycle analysis on the production of Polyhydroxyalkanoates (PHAs) from (1) corn by fermentation, and (2) in genetically modified corn. Both studies strongly suggest that making PHAs from renewable resources, using current energy usage patterns, have an overall negative environmental impact when compared to conventional polymers such as polystyrene or polyethylene. We conclude that biodegradability per se also has environmental tradeoffs and offer a life cycle view of possible alternatives.

PROGRAMS OF THE U.S. NATIONAL SCIENCE FOUNDATION: AN OVERVIEW

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The National Science Foundation (NSF), which was founded in 1950, is the single national agency in the United States with the sole mission of supporting basic research and education in science and engineering. The Foundation is governed by the National Science Board, and its Director is appointed by the President. NSF does no research in-house; rather it is one of the primary sources of funding for research in American universities. The total budget for the current fiscal year is US $ 4.4 billion.

The activities supported by NSF are organized around three basic themes: people, ideas, and tools. All proposals for funding are reviewed by the peer community and evaluated in terms of two general criteria: intellectual merit and potential impact.

In this talk I shall explain briefly the organization and operating procedures of NSF as well as some of the programs that may be of interest to this audience. In particular, I will describe the research initiatives that have a bearing on understanding and protecting the environment. One current initiative of NSF is called “Biocomplexity in the Environment”, and there is a major effort on Environmental Research and Education. An Engineering Directorate program that is run jointly with the Environmental Protection Agency, “Technology for a Sustainable Environment”, seeks to promote research on pollution prevention, with an emphasis on Green Chemistry and Engineering.

In addition to supporting domestic academic research projects, NSF also encourages international collaboration. There is a Division of International Programs that serves as the U.S. point of contact for bilateral and multinational science agreements. Although NSF does not support foreign research activities, the International Division and the disciplinary programs do provide incremental support to facilitate international collaboration by our scientists and engineers. These activities are aimed not only at enhancing research progress but also at human-resource development.

In this talk I shall try to identify opportunities through NSF for increased cooperation between U.S. and European colleagues with common interests, such as the development of clean products and processes.

Professor Thomas W. Chapman, U. S. National Science Foundation, explaining NSF activities

COMPUTER DEMONSTRATIONS

NATO/CCMS CLEAN PRODUCTS AND PROCESSES WEB SITE. U.S. EPA - LCACCESS

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The NATO CCMS Pilot Study on Clean Products and Processes web site and U.S. EPA's LCAccess web site will be demonstrated.

The Pilot Study web site (http://www.epa.gov/ord/NRMRL/nato) contains background information on the pilot study, electronic copies of the annual reports, and information on each nation actively involved in the study.

The U.S. EPA's LCAccess web site (http://www.epa.gov/ord/NRMRL/LCAccess) was recently established by the National Risk Management Research Laboratory and is a portal to on-line life cycle assessment (LCA) data. The purpose of the site is to promote LCA and to provide a single point of departure for accessing the wide range of data available from sources all over the globe. By demonstrating the site, U.S. EPA hopes to encourage use and participation by the national delegates.

Computer demonstration

ENVIRONMENTALLY FRIENDLY TECHNOLOGIES DATABASE

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The presentation is devoted to some of offered by the author more than 300 inventions at ecologically friendly technological processes, among which many are developed within the framework of CP program for working manufactures, are submitted in database “Commercialised CP Technologies Virtual Market” (http://www.zadorsky.8m.com). There are the next groups of the processes:

Commercialized environmentally friendly technologies

- Extension of Ecologization Concept to Cleaner Production
- Catalyst impregnation
- Impregnation of electrodes and other carbon/graphite articles
- Impregnation of textile fibers, and fiber reinforcements of resin-matrix composites
- Solid-liquid extraction for pharmaceutics, food processing and pulp industry
- Adaptation and rehabilitation program of ecologically intense zones inhabitants
- Ecological Equipment and Environmental Protection
- Elaboration of the ecologization conception of cleaner production
- Electroaerosole Equipment and Methods
- Flexible Manufacturing for Chemical Processing
- Natural and Wastewater Treatment Technology and Instrumentation
- Pollution Control Equipment and Environmental Protection
- Pulsed Voltage Converter for Electric Filter Power Supply
- State-of-the-Art Approaches to Aerobic Fermentation Engineering
- The program and experience of education retraining at theory and practice on cleaner production
- Treatment of Natural and Waste Water

Manufacturing

- Converter of a Voltage's Pulsing to Power Supplies of Electric Filter
- Flexible Production Systems
- Electrosol painting

Equipment and Materials

- Acoustic Equipment for Intensification of the Mass-Transfer Processes
- New Impregnation Thermotechnology of Production
- Technology for deep purification of liquids
- Electrosol Apparatuses and Methods
- Flexible Manufacturing Systems for Chemical Processing

Utilities

- Improving water quality through low-cost upgrading of a water treatment facility accompanied by abandonment of chlorination

ON-LINE VIRTUAL CLEANER TECHNOLOGY INCUBATOR

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One of the most perspective directions of mutually beneficial collaboration is a creation of the Virtual on-line TECHNOLOGICAL CP BUSINESS-INCUBATOR (VTBI-CP) “INTELLECTUAL SERVICE”. VTBI-CP will be a commercial NET with the next basic blocks:

- Virtual Investment Market of enterprises and organizations (which want to invest) web-sites/pages, Internet Data Base of professionals and organizations in the field of investment expertise, search engines on and links to investment legislation in different countries, Web pages on and links to investing institutions and individuals (*i.e.* funds, banks, state organizations, investment companies and corporations, etc.), information in Internet on grants, subsidies, sponsor help, Web-page/sites, business proposals and projects’ plans pulled out for investing).

- Technologies Transfer Market (search engine systems on patented information in different countries, Web - Page/sites, presentations on technologies transfer in the different fields).

- Services (scientific and technical consulting, audits, examination, project management, search for partners, search for investors, grant programs, tenders, advantageous credits, etc., support in fundraising, legal service, patenting, examination and consulting on scientific and technical solutions to improve industrial technologies and equipment, to solve ecological problems as well energy-saving ones, etc., business-planning, Web site design on international standards, preparation of projects, international conferences, exhibitions and fairs’ presentations in INTERNET and mass media).

- Training and consulting (on-line training programs on business, foreign languages, management, marketing, decision making theories, system analysis, theories of system sustainable development, work in Internet, consulting services, links to universities involved in activity similar to VTBI subjects).

Besides wide program of mutually beneficial collaboration will be offered: joint scientific research, including participation in international scientific programs and joint developments for industrial enterprises and other organizations, transfer of new high technologies, joint analysis of developments in science, industry, education and social policies in the NIS countries, joint research in permanent areas of applied chemistry, chemical processing and chemical engineering, chemical industry, metallurgy, engineering, food-processing and pharmaceutical industries, exchange of leading scientists and specialists, exchange of visiting professors that deliver lectures on the chosen themes.

FOSTERING RESOURCE EFFICIENCY THROUGH NETWORKING AND CONVENIENT INFORMATION ACCESS – GERMANY'S CLEARINGHOUSE COOPERATIVES ON CLEANER PRODUCTION IN THE WORLD WIDE WEB

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The access to technology and management information is crucial for further implementation of cleaner production processes in companies. With two new Internet gateways, Germany supports this demand to foster sustainable development in industry. The German Federal Environmental Agency (UBA) has established the first version of the website "www.cleaner-production.de". Cleaner Production Germany (CPG) is a federal Internet information system for innovative environmental technology and federal projects in Germany and a gateway to technology transfer and contacts. The PIUS Internet Forum under www.pius-info.de is closely linked with CPG. It is a cooperative web project of currently five German states with new partners to be acquired. The large database of pollution prevention projects conducted in companies offers detailed information about technology, experiences, costs and management. By extending the two cooperating Internet platforms Germany wants to boost international environmental and development cooperation and promote the transfer of environmental technologies.

POSTER PRESENTATIONS

CLEANER PRODUCTION OF FARMERS AND FOOD PRODUCERS IN THE CZECH REPUBLIC

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Principles of cleaner production in agricultural and food industries are introduced in the Czech Republic through the projects of cleaner production. The projects are aimed at family farms, co-operative farms and food-processing companies of different sizes. Projects of the Czech Cleaner Production Center are implemented not only in individual companies, but also within the framework of regional programs. Regional program is the instrument of municipal environmental policy that helps to support sustainable development.

Five papers present the following topics: regional program of cleaner production and the scheme of its implementation procedure, examples of project implementation on a farm, in a co-operative farm and a food delivering company, and the activities of the Czech Cleaner Production Center.

ENVIRONMENTAL IMPACTS OF HC EMISSIONS IN LIFE CYCLE ANALYSIS OF GASOLINE BLENDING OPTIONS

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Changes in gasoline specifications worldwide affect demand for all major gasoline-blending components. The purpose of this study is to compare different gasoline formulations based on the accounting of the environmental impacts due to hydrocarbon emissions during the gasoline production and marketing. Gasoline blending streams used to meet all the specifications are:

reformate, alkylate, cracked gasoline and butane. The two most important variables to consider in the gasoline blending are the research octane number (RON) and the Reid vapor pressure (RVP) which are subject to technical and environmental constraints. This study considers two gasoline octane grades, the 95 and the 98 RON. Among these two gasoline grades several formulations will be compared, i.e., with a different content of butane, reformate, alkylate and cracked gasoline. In doing the several gasoline formulations it is important to meet the RVP requirements defined by the EU Fuels Directive. This study accounts the gasoline losses due to evaporation and leaks, using existing methods in the literature, and evaluates the potential environmental impacts, using the Waste Reduction (WAR) algorithm. It includes eight impact categories: human toxicity by ingestion and by dermal/inhalation routes, terrestrial toxicity, aquatic toxicity, photochemical oxidation, acidification, global warming and ozone depletion. This analysis includes the several steps in the gasoline life cycle: the manufacture, storage, loading in tank trucks, loading in tankers or barges, transit losses during the transportation of gasoline to service stations, storage at service stations and vehicles refuelling. This study also considers the variation of the operation conditions of the reforming process, to adjust yield versus octane number, using process simulation. The calculated values are good estimates of the real process allowing different aspects to be easily analyzed. Several conclusions came from this study, concerning an environmental evaluation of the different gasoline options and formulations and about the operation conditions that should be used in the reforming process in order to met the gasoline specifications.

CERAMIC MEMBRANES IN CLEAN PROCESSES IN RUSSIA

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The development of inorganic membranes in Russia began in early 40-s of XX-th century and the main industrial application was the separation of gases. In the 80-s of the last century various research groups and industrial enterprises were concentrated due to special program, financed by government, for the development of ceramic membranes technology, production and realization of membranes and units. Due to this program the technologies of micro-, ultra- and nanofiltration ceramic membranes based on Al_2O_3, ZrO_2, TiO_2, SiO_2, CeO_2, SiC were developed and various processes and applications were studied. The first industrial output of ceramic microfiltration membranes started in 1989 in Moscow region. The rate of ceramic membranes production in Russia (100 m^2 in 1989) reached 950 m^2 in 1993 and 2 100 m^2 in 2000. Basic industrial applications, designs and technological data of ceramic membrane units for clean products and processes in food industry (purification of wines, juices, vodka etc.), pure and waste waters treatment, microbiological and pharmaceutical branches of industry (filtration of biomass, culture broths etc.) are discussed.

TOOLS AND METHODS FOR CLEAN TECHNOLOGIES

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The scientific analysis of the production interaction with the environment allows to estimate the direction toward improving the technological processes, which would reduce their negative influence on the environment, it is possible only based on system-structural analysis of the ecologization of production. Then it would be possible to consider the interaction between nature and man based on a complex systematic approach founded on the apprehension of the fact, that the technical equipment is only a part of the all system. Therefore the tendency to harmonize the relationship of nature with technical equipment, where the operation of industrial complexes is tied not only to the technogenic activity of man and the use of technological objects, but also to the state of natural environment becomes evident. The ideal solution of the problem would be the creation of nature-technical system allowing to achieve high technical indices at favorable ecological condition.

As it is often impossible to reduce the level of negative influence of the production on the environment without modifying of the technological processes, the activity to improve the current ones or creating principle new technological processes directed not only to solve the utilitarian problems, but also to protect the environment.

Approach to global ecological crisis compels to take into consideration the influence of industry on environment. It's need a quantitative indexes characterizing the influence not only for estimation measure of influence of the production but for prognosis of technogenic influence of the enterprises being projected or for securing given level of technogenic influence.

A classification scheme is developed, showing the interrelation of the main conceptions of ecologization of the production with the methods of their realization.

ENVIRONMENTAL BIOTECHNOLOGY IN THE QUESTOR CENTRE

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This poster outlines the various strands of environmental research in the QUESTOR Centre (Queen’s University Environmental Science and Technology Research) that have a biotechnology aspect.

THE QUEEN'S UNIVERSITY IONIC LIQUID (QUILL) RESEARCH CENTRE

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This poster describes the features of the QUILL Research Centre. It includes a brief description of ionic liquids, the areas of IL research in QUILL and also charts showing, respectively, the growth of papers on ILs over the past 20 years and the IL publications by author to date.

CATALYTIC TREATMENT OF GASEOUS EMISSIONS FROM COKE OVENS

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Introduction

Many of the gaseous emission problems in the iron and steel-making industry have been solved by improving the existing production technology or by adopting suitable treatment technologies. In the last years great progress has been made in controlling dust emissions. Dust is controlled by protecting open piles, watering roadways, covering conveyor belts and transfer points, controlling fumes through improved casthouse practices and air cleaning systems ducted to bathhouse or other filtration systems. Sulfur dioxide emissions are controlled using off-gas and stack cleaning systems. Great progress has also been made in controlling fugitive emissions (emissions that enter the atmosphere from other places than a stack, chimney or similar device) such emissions occur when pollutants are not captured by a control device or are generated without employing control measures. Significant sources of fugitive emissions in the iron and steel industry include coke ovens, sinter plants, blast furnaces, steel converters, teeming, casting and rolling plants. For instance, recent technological developments for reducing coke oven fugitive emissions include leak-free oven doors and hoods for collecting emissions during coke oven charging and pushing.

There still exist, however, several emission sources of gaseous pollutants for which treatment is lacking or not satisfactory. As a matter of fact, while sulfur dioxide and particulates are usually eliminated from controlled emissions, treatments for eliminating other chemicals are often incomplete, specially for volatile organic compounds (VOC). In the other hand, there are still numerous sources of uncontrolled fugitive emissions in the iron and steel plants.

One example of this type of emissions is given by the coke production process. Most of the gas generated during the coking process is suitably collected and treated, but other emissions are produced by leakage from coke oven doors and during the charging and discharging processes. These emissions contain dust, inorganic gases, such as H_2S and NH_3, CH_4 and VOCs including toxic ones: ethylene, propylene, toluene, xylene and benzene. In the last years, the concerning about the methane emissions increases a lot, because of the important role of this compound in the global warming.

Other significant sources of fugitive emissions (in the iron and steel industry) include sinter plants, blast furnaces, steel converters, teeming, casting and rolling. Besides, the composition of these gaseous emissions varies according to the location of the leak and varies also with time, as they are related to non-steady state processes or to accidental emissions.

All these emissions, although being considered small in comparison with the total volume of emissions in this type of industry, represent a considerable impact on the environment, taking into account the size of the European iron and steel industry and the hazardous character of the compounds released. In view of an increasingly deeper control of the atmospheric pollution, required both socially and by the ever more restrictive environmental regulations, it is necessary to treat them using adequate "end-of-pipe" processes.

The USA classified these emissions as hazardous air pollutants under the Clean Air Act. According to the EEC Protocol on VOC Emissions, signed in November 1991 by 23 European countries, VOC emissions should be reduced by 30% by the year 2000 (with regard to the base year 1988). The committed countries also agreed on imposing maximum emission standards on their industries by 1994**.** Furthermore the best available technologies for an economical VOC removal must be installed by 1997 in all existing companies. These new targets on VOC emissions can no longer be achieved in an economical and cost efficient way with the current technologies of active carbon adsorption and thermal incineration, and existing catalysts for catalytic incineration must be adapted to the specificities of the gaseous emissions generated by the iron and steel industry.

Although the production of coke in the iron and steel industry might become superfluous in the future due to the development of the so-called "direct reduction" technology, it is widely accepted that the blast furnace process will remain dominant during at least the next 30 years.

Coke oven emissions

The results here presented correspond to a Research Project, financed by the European Union with the participation of Aceralia Corporación Siderúrgica, the main iron-making company of Spain, the Catholic University of Lovaine (Belgium) and Technical University of Turin (Italy). The scope of this project was the study of the coke oven emissions. Three important fugitive emissions are produced in the operation of a coke oven (Fig. 1):

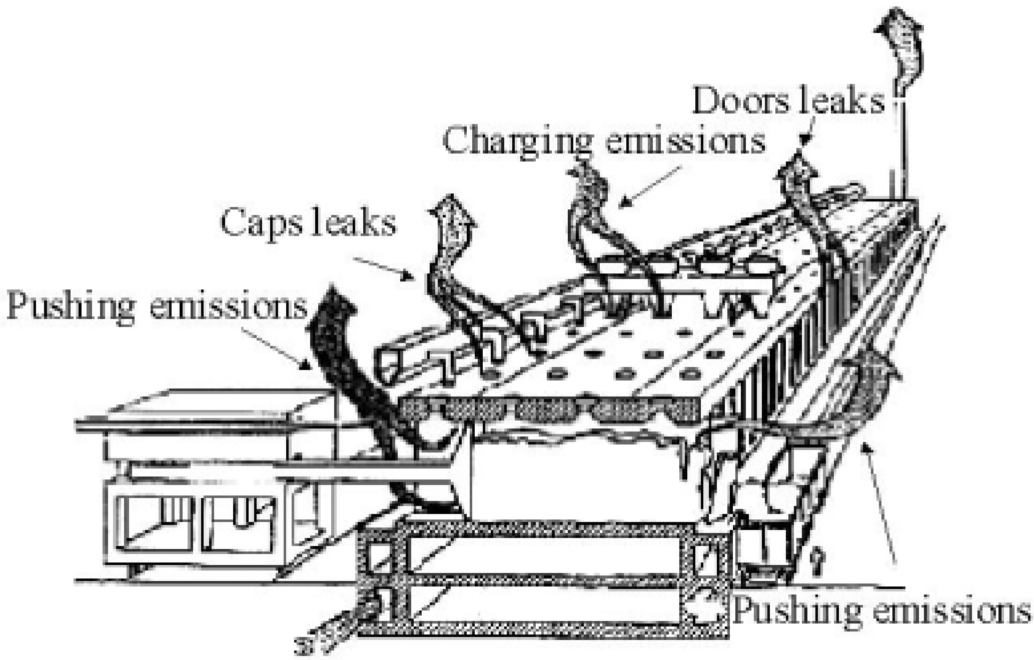

Figure 1. Main coke oven emissions

1. *Emissions produced in the pushing of the coke*. These emissions are the less important from an environmental point of view, the main pollutant detected were CO and specially CO_2, produced by coke combustion in presence of air.

2. *Emissions from leaks of oven caps and doors*. These emissions are the most pollutants, they content high amounts of VOCs, PAHs, and sulfur and nitrogen compounds. The caption and treatment of these emissions is very difficult, but these emissions are avoidable with a good maintenance of the ovens.

3. *Charging emissions.* These emissions are the gases contained in the empty oven, which are displaced when the oven is charged with coal. The device utilised to coal charging has a blower to extract these gases. The pollutants found in these streams are the same than in the case of leaks, the concentration depending strongly on the blower performance.

Typical compositions of the three emissions are shown in Table 1. The most important emissions are the charging emissions since they are unavoidable and they present important concentration of pollutants. Furthermore, charging emissions are water saturated because of the use of a water shower to remove particulates from the emissions.

Table 1. Typical composition of coke oven emissions (ppmV). Details about analytical methods are given in references [2,3]

Compound	Charging emissions	Pushing emissions	Leaks emissions
CO	1500	210	3120
CO_2	1450	57800	2890
CH_4	2710	"	18800
H_2S	15	"	55
SO_2	23	"	40
NH_3	176	"	545
NO_2	29	"	23
C_2H_4	"	"	1950
C_2H_2	"	"	1570
H_2	"	"	33000

However the treatment of these emissions must afford another problem which is not present in the treatment of other polluted gaseous streams: their unsteady character. These emissions are produced during 3 minutes (with no constant flow and concentration), with a variable time interval, which depends on dimensions of coke oven, coal residence time and other operational factors.

Treatment technologies: catalytic incineration

Although many technologies are described in the literature for the abatement of organic compounds in gaseous emissions [1], the flow and composition of the studied emissions make difficult the technology selection. Gas adsorption is not efficient for light hydrocarbons (such as methane), the operation of biofilters is hindered by the presence of sulfur and nitrogen inorganic compounds, whereas thermal incineration is not appropriate because of the needing of big amounts of additional fuel (which could be very dangerous in the environment of a coke oven battery).

Catalytic incineration seems to be the most interesting alternative, in spite of the pernicious effect of the sulfur compounds on the performance of the most of the catalyst [4]. It is important to remark that methane is considered as the organic compound most refractory to catalytic oxidation. Due to this reason, subsequent studies are centred in the catalytic oxidation of methane, all the other VOCs being removed at conditions need to methane oxidation.

Although catalytic oxidation is a very studied and utilised technique, there are not studies about the behaviour of the catalysts at these aggressive conditions. So the first part of our work was devoted to test the available oxidation catalysts in lab reactors.

Three aspects have been considered: the activity for methane oxidation, the catalyst resistance to deactivation in this environment and the effect of the cyclic working in the catalyst performance and deactivation. The selected catalyst has been tested *in situ* in a bench scale reactor.

Experiments in a lab-scale reactor

The lab-scale reactor used in this work is a stainless cylinder of 400 mm length and 9 mm internal diameter. Catalyst (typically 0.3-1 g) is diluted with inner glass is placed in the middle section of the reactor, the upper and lower parts of the reactor being partially filled with additional packing material. The reactor is placed inside an electric furnace. Reaction temperature is monitored by a thermocouple placed inside the rector and controlled by a PID controller, acting on the electric furnace. The reactor feeds are produced by mixing gas streams coming from gas cylinders, when liquid reactants are used (i.e. water), they are fed using a precision syringe pump. Reaction products are analysed by gas chromatography.

1. Catalyst screening

The following catalysts have been chosen to be studied for the destruction of methane and other pollutants:

Precious metals catalysts:
RO-25/50 BASF, 0.50 wt.% Pd/Al_2O_3
Escat 26 ENGELHARD, 0.50 wt.% Pt/ Al_2O_3
Escat 36 ENGELHARD, 0.50 wt % Rh/ Al_2O_3
211 H/99 SÜD-CHEMIE, 0.1 wt % Pd, 0.1 wt % Pt/ Al_2O_3

Metal oxides catalysts:
R3-20 BASF, CuO 7 wt.%, Cr_2O_3 14 wt.%, TiO_2 71 wt.%

In order to select the best commercial catalyst, light-off curves and ageing experiments in presence of a hydrocarbon, a sulphur compound (hydrogen sulfide) or a nitrogen compound (ammonia) were carried out in a fixed bed reactor. Details of the experimental set-up and analytical procedures were given in reference [5]. The reactor was fed with 2000 ppmV methane in air. In the light-off curves the space time in all experiments was 2.3 min g/mmol methane, except for the BASF mixed oxides catalyst, for which space time was increased to 15.2 min g/mmol methane. In the case of ageing studies the selected temperature was 450ºC for all catalysts (except for the mixed oxides one, for which temperature was fixed at 600ºC). Space times used in the ageing experiments for the different catalysts were varied between 2.3 and 15.2 min·g/mmol, depending on the catalyst activity. Some results are presented in Figs. 2 and 3.

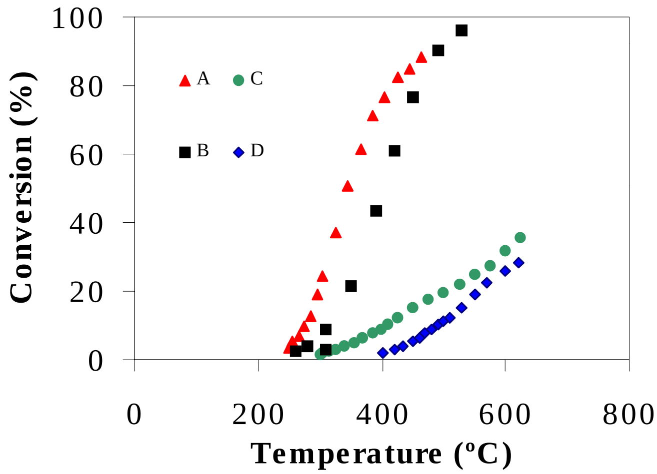

Figure 2. Light-off curves for the selected catalysts: A: RO-25/50 BASF, B: Escat 36 ENGELHARD, C: 211 H/99 SÜD-CHEMIE, D: R3-20 BASF

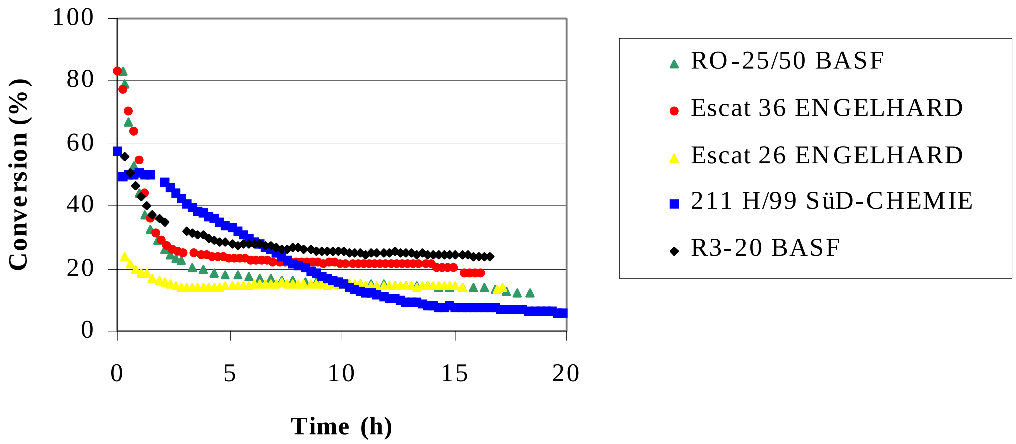

Figure 3. Ageing experiments with the selected catalysts

The following conclusions can be obtained from these experiments:

- The most active catalysts for the deep catalytic oxidation of methane are the catalysts containing palladium and rhodium.
- Palladium and rhodium catalysts suffer a sharp deactivation during the first hours of experiment, conversion decreasing then slowly. On the other hand, although the decrease in conversion for the platinum and mixed oxides catalysts is less pronounced, the conversion is very poor at the same experimental conditions

According to these results, the palladium catalyst was selected to be studied more in depth. In other hand, the two inorganic compounds that affect the catalyst performance in higher extension are shown to be water and sulphur compounds.

2. Cyclic studies

These experiments were carried out using the selected palladium catalyst. The experimental conditions were the following: space time: 11 g.min/mol; temperature: 450ºC; concentration of pollutants: 5000 ppm methane, 65 ppm SO_2, 27000 ppm H_2O, 180 ppm NH_3. Results for the methane-water mixture show that the catalyst recovers its initial activity when steam is removed from feed. On the other hand, results in the presence of SO_2 indicate that the recovery in the catalytic activity is only partial when SO_2 is not fed to the reactor (Figure 4).

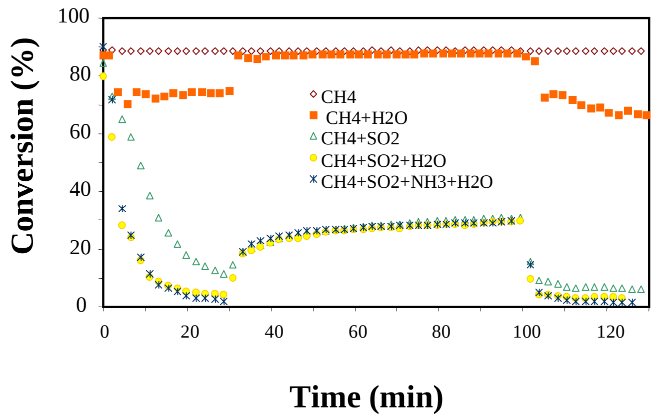

Figure 4. Cyclic studies

Experiments in a bench-scale reactor

A bigger reactor was designed and constructed in order to carry out experiments of catalytic combustion with the real gaseous effluent in an industrial coke oven battery.

The main characteristics of this equipment are summarised below:

- Reactor: stainless steel tube with 50 cm length and 22 mm internal diameter. Heating by a cylindrical electric oven.
- Temperature control: P.I.D. controller able to provide linear and step perturbations of the set point.

For the experiments in the industrial plant, a vacuum pump was used to provide the gas flow through the experimental set-up. The flow rate was measured by a rotameter.

The set up was installed in the driver cabin of the larry car (the moveable device that charges the coke ovens). The reactor system (Fig. 5) consisted of a gas capturing and feeding system, specially designed for the plant (rotameter, filters and vacuum pump), that captured the emissions from the stack, and the bench scale fixed catalytic bed. Gas samples were taken by means of glass bulbs located both at the reactor inlet and outlet, and analysis was performed by gas chromatography.

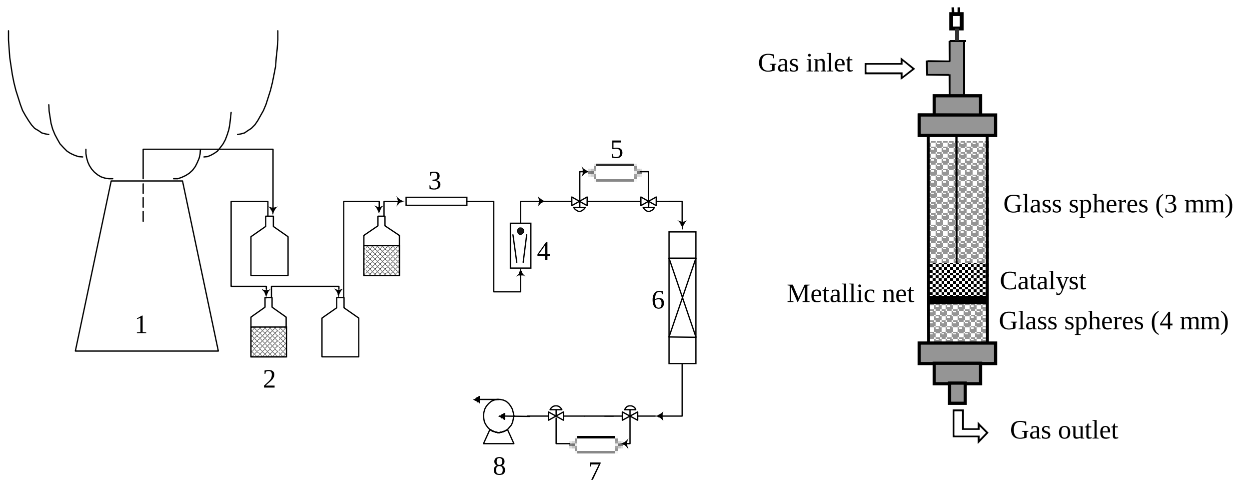

Figure 5. Scheme of the reactor and of the experimental set-up used in the plant experiments: 1. Exhaust gas, 2. Particle removers, 3. Filter, 4. Rotameter, 5. Inlet gas sampling, 6. Reactor, 7. Outlet gas sampling, 8. Pump

Two sets of experiments were carried out, both with the selected commercial catalyst (BASF 0.5% Pd/Al_2O_3). The first set of experiments was carried out at high space time (0.029 $s{\cdot}m^3cat/Nm^3$) and two different temperatures (450 and 550ºC), for up to 15 successive cycles of operation. Each cycle lasted aprox. 4 min and they were spaced aprox. 10 min. The aim was to confirm the ability of the reaction system to get high conversions in the catalytic combustion of methane for the real effluent. In these experiments a good performance of the system was observed, as can be seen in Fig. 6, the methane concentration at the reactor outlet being always lower than 18 ppm, for inlet concentrations ranging between 100 and 6000 ppm. In spite of the presence of sulfur compounds in the reactor feed, no important catalyst deactivation was observed during these experiments. This is confirmed in Fig. 7, in which it is observed that methane conversion does not depend on the number of cycles of operation. This figure shows as well that the lower the inlet methane concentration, the lower the conversion obtained (result expected, from the point of view of the lower heat of reaction generated at low concentrations).

The second set of experiments was devoted to study the deactivation for the catalyst at lower space time in real industrial conditions. For this purpose, a low space time (0.0089 $s{\cdot}m^3cat/Nm^3$) was selected, in order to observe the deactivation of the catalyst. The results are shown in Fig. 8, where the catalyst deactivation with the increase of operation cycles can be observed, if data obtained for very low methane inlet concentration (an hence low conversions) are discarded.

Conclusions obtained in the real plant agree with those obtained in the lab experiments, indicating that the strategy of studying the behaviour of the catalyst at lab scale with synthetic gaseous mixtures of different complexity was adequate.

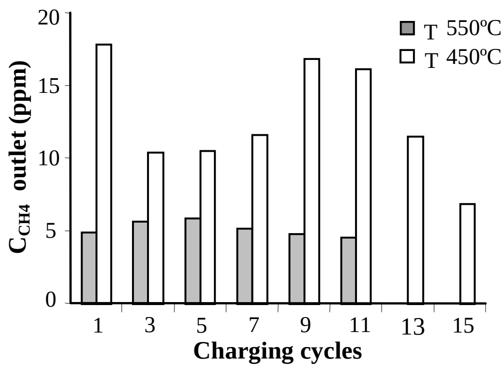

Figure 6. Methane concentration in the outlet of the reactor

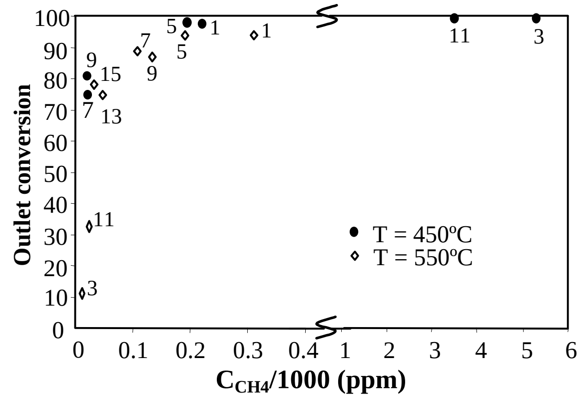

Figure 7. Conversion vs. outlet methane concentration (small digits indicate the number of cycles)

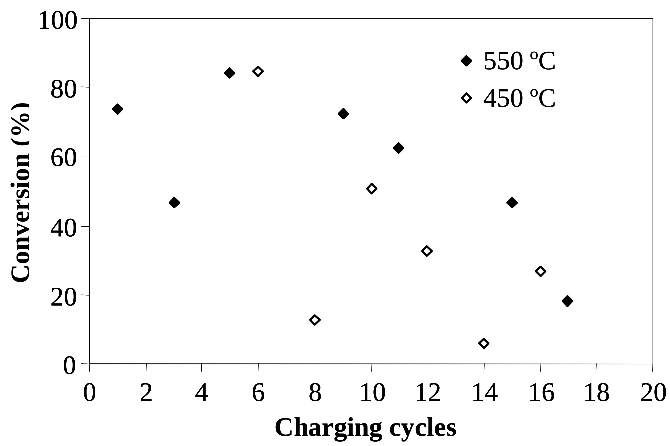

Figure 8. Methane conversion vs. number of charging cycles. Experiments at low space time

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UNIVERSITY-INDUSTRY CO-OPERATION PRESENTATIONS

QUESTOR/QUILL UPDATE

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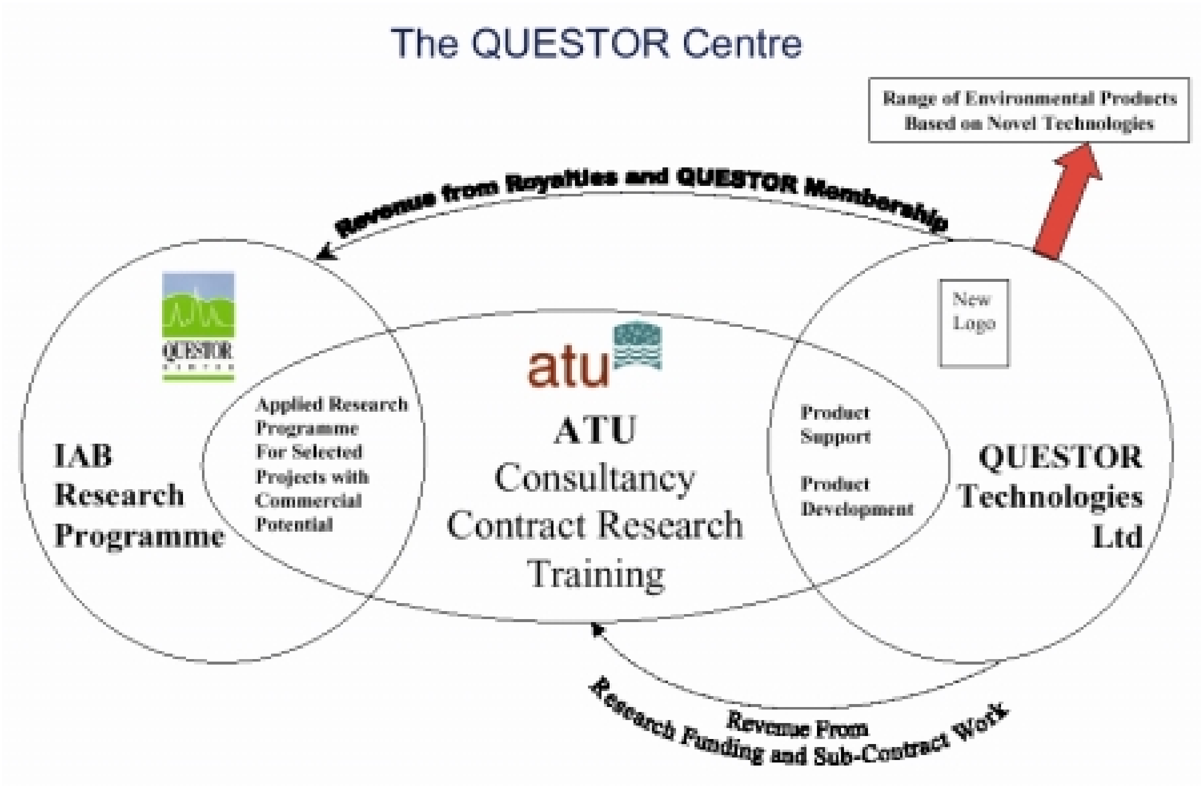
This presentation will outline the current status of both the QUESTOR and QUILL Industry/University Co-operative Research Centers (IUCRC). In addition the development and operation of the new Applied Technology Unit (ATU) of QUESTOR will be described and in addition the progress made founding QUESTOR Technologies Ltd, the spin out company with three environmental products arising from research within QUESTOR.

Progress with the establishment of QUMED, the new IUCRC for medical devices combining medicine, engineering and science in Queen's University will also be described.

Professor Jim Swindall, Queen's University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Range of Environmental Products Based on Novel Technologies
Revenue from Royalties and QUESTOR Membership
IAB Research Programme
Applied Research Programme For Selected Projects with Commercial Potential
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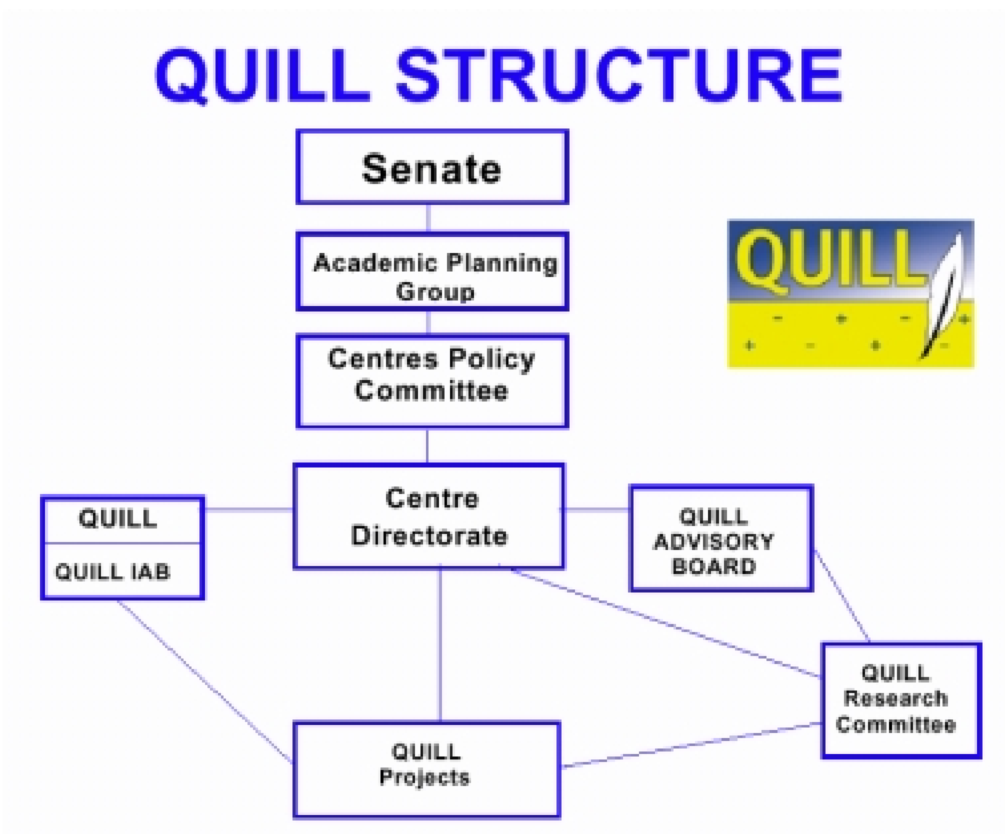
ATU Consultancy Contract Research Training
New Logo
Product Support
Product Development
QUESTOR Technologies Ltd
Revenue From Research Funding and Sub-Contract Work


QUILL STRUCTURE
Senate
Academic Planning Group
Centres Policy Committee
Centre Directorate
QUILL
QUILL IAB
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UNIVERSITY/INDUSTRY RELATIONS IN SPAIN

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The university in Spain is one of the oldest institutions in the country and in Europe. As an example, the University of Salamanca, founded in 1254, boasted above ten thousand students in the fourteenth century, and played an important role in many historical events, like the discovery of America by Columbus. The role of the old universities for many centuries was to give advice to the kings and queens, to work on new laws and to educate the future priests for the church.

For many centuries, and perhaps till the second half of the XX century, the main issue of the Spanish universities was to provide society with professionals that could find jobs in the administration, industry, educational institutions, services and some private initiatives. In the period 1950-1975 some research efforts were made in the university sponsored by very modest state programs, always carried out with a lack of infrastructure and equipment, and with no communication channels with industry.

In that period of time the Spanish industry supplied the goods to the national market and the protectionist barriers towards imports, made out of most companies “production tools”, in an environment with no competition from other nations. As a result, there was no incentive for scientific and technological innovation and also no basic need for a partnership of universities and industry. The research carried out in the university was mainly basic research, of limited scope, and in areas based on the interests or skills of the professor.

Roughly, in the last quarter of the XX century, an increasing funding of research activities was established and working relationships between companies and universities increased and were enhanced by European, national and regional research programs.

The aim of this article is to describe the major changes undergone by the Spanish universities in the last 25 years, the main sources of research funding and their implications in promoting university-industry cooperation.

The evolution of Spanish universities

The last quarter of the XX century has been a period of time of big changes in the Spanish universities. Until the late 60´s there were in Spain 12 public universities and 2 private ones. The student population in each university was well below 10 000 students, with the exceptions of Madrid and Barcelona that had a larger number. The university consisted of Faculties of Humanities, Sciences, Medicine and Law and Schools of Engineering and Architecture. There was a departmental structure, and very often the department had only one full professor, 2 -10 assistant professors and several teaching assistants. Tuition in those days was of the order of 3000 pesetas (18∈, of year 2000) per academic year. The departmental budget was very low and it was spent in buying a few books and journals and to support laboratory courses.

Along those years and till the present days the number of Spanish universities has increased to 58 in the public sector and 8 in the private sector. The constant pressures for demand of university studies has increased the number of students in the small universities quite often up to 40.000. The expanding number of students and knowledge, the urgent need of more professors and the more research-oriented university has brought radical changes in the university structure in the last 25 years. The departments have now several full professors, a larger number of assistant professors, but fewer teaching assistants, because of their fast promotion. Tuition has also increased and on the average is now 100 000 pesetas (590 ∈) per academic year, still low if compared with American public universities and some European. The departmental budget has also increased and new chapters are available such as: infrastructure, equipment and library.

In the year 1983 a new University Law was approved by the Spanish parliament (Ley de Reforma Universitaria, LRU). The law was intended to accommodate the university structure and organization to the changes and demands of the society and had a substantial impact on how the rector was elected and how professors were appointed. It also created new decision bodies and, last but not least, established the framework for the university-industry relations, that did not have a legal support till the new law LRU was passed.

Another keystone for promoting research in the university and other research institutions was the Science Law which was proclamed in 1986. A science and technology committee called CICYT (Comisión Interministerial de Ciencia y Tecnología) was established as a result of the new law, with representation of the different ministries involved in science and technology activities. In 1998 a science and technology agency, OCYT (Oficina de Ciencia y Tecnología), was established which works closely with CICYT in the planning, coordination and evaluation of science and technology activities.

Research schemes for collaborative research with industry

In Spain R&D activities are carried out at the University, National Research Council (CSIC), Industry and Research institutes. The number of researchers is roughly 100.000 of which 30.000 are at the university, 20.000 at the CSIC, 35.000 in industry and 15.000 at research institutes. The number of researchers is of the order of 6% of the active population, lower than in other European countries with similar economic standards.

The research budget of all the Spanish universities is 190.000 Mpts (1.188 M∈) and 110.000 Mpts (0.688 M∈) for CSIC and research institutes. The total research expenses account for 0.9% of the IRP, well below the United States and Japan (3%) or Germany and France (2.5%). More than 60% of the published research is carried out at the university.

Every three years a national research plan is established and usually coordinated with the research priorities of the research programs of the EU. The present one corresponds to the period 2000-2003 and is coordinated with the Fifth Framework Program of the European Commission. There are three basic sources for research grants:

- National programs: CICYT, Ministry of Environment, etc.
- Center for Industrial and Technology Development (CDTI)
- Regional programs: Science and Technology Foundations (FICYT, etc)
- European Union programs: FEDER, BRITE, etc.
- Industry

Project proposals applying for funding in the national and regional programs are sent to the national evaluation agency (ANEP) and granting for those approved is decided by specific committees. The CDTI is basically an industrial source for financing through low interest loans development projects carried out by industry, eventually with some cooperation from research institutions.

The regional programs try to promote collaborative research and development projects with industry, and usually 60% of the budget goes for that purpose. The industry is required to participate with at least 10% of the total funding of the project. The regional programs have been very useful to promote regional development and regarding cooperation with the local companies, that sometimes do not have the critical size to do their own research. Through the regional programs researchers doing basic research have found incentives towards working with industry.

The European Union research programs have also been very useful for the cooperation with some Spanish companies. Working with other European partners is always very stimulating and gives a major incentive for universities and industry to work together.

Research projects supported by industry and to be carried out in the university are still very scarce in Spain. Most of them are of applied research, and have to be carried out at the most in one year period, which is too short taking into account the university structure, based mainly on students as research personnel. The overhead costs hold by the university are 12% of the total project amount.

There are still some problems to reach an optimum collaboration between industry and universities, such as: university pressures for publication of results, low funding for applied research, no secure sustainability of an applied research project once the program comes to an end, lack of efficient interface structures for technology transfer and scarce research support by multinational companies operating in Spain.

SPECIAL TOPIC PRESENTATIONS ON ENVIRONMENTAL CHALLENGES IN PROCESS INDUSTRIES

PRINCIPALITY OF ASTURIAS: ENVIRONMENTAL POLICY

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In the last century, the world has suffered an extraordinary development, reaching high levels of social welfare. The increase on production and consumption implies the possibility of depletion of the natural and energetic resources and the impossibility of the natural regeneration mechanisms to accept the environmental impact.

The situation on the region of Asturias is no different to other parts of the country. The circumstances that we live show the conflicts that the human being has created in our environment.

The establishment of the Environmental Council by the Government of the Principality of Asturias reflects the importance that the environment has taken in the last years. It is established as a unique management body, dealing with all the environmental issues of the regional administration.

The objectives of this administration are to find, study and give solution to the environmental problems relevant to Asturias. To approach such problems the structure of the Environment Council is divided in three main areas: water, environmental quality, and natural resources.

The general lines of action consist of:

- Integration of the environment on the rest of the politics
- Inter-administrative co-ordination
- Improving the enforcement of the environmental regulations
- Raise public awareness and support public collaboration
- International collaboration
- Re-orientation of the market mechanisms
- Environment as a development element
- Environment, research and development.

Some of the work carried out so far by the Environmental Council is as follows:

- Implantation of a wastewater tax to be able to cope with the expenses of investment and maintenance of the plants
- Creation of a wastewater treatment committee
- Project and construction of a composting plant for organic waste
- Investment to improve waste treatment facilities
- Regeneration of contaminated soils
- Collaboration between administration and the main industries for improving the air quality
- Clean up of rivers from any possible obstacles for the fish
- Construction of salmon scales on main reservoirs to promote the growth of the salmon
- Awarded two Biosphere Reserves by the UNESCO
- Design of a web page for public information
- Establish a new natural park
- Plans for the recovery of the bear, etc

ADVANCES IN ENVIRONMENTAL ASPECTS OF DESALINATION: THE CANARY ISLANDS EXPERIENCE

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The Canary Islands Water Center is a foundation, created by the initiative of the Canary Islands Government in 1998, with the support of the Water Councils of the seven islands of the archipelago and several private companies working in the Canary Islands in the water related subjects.

The first desalination plant (MSF type) was constructed in Lanzarote in 1964. Today, over 300 plants of different sizes, from 100 m^3/day to 40 000 m^3/day, produce more than 133 hm^3/day (32.5 mgd) of desalinated water. About 70 % of the feedwater is sea water, either from direct intakes or from beach wells. The remaining feedwater is mostly brackish water from coastal wells. Few plants desalinate also highly bicarbonated mountain water on the island of Tenerife. Most of the plants (approx. 90 %) are reverse osmosis (RO) plants.

This presentation reviews some data in relation to brine discharge and feedwater intake, as well as advances in the use of renewable energy for desalination and recent developments in energy recovery devices for RO units.

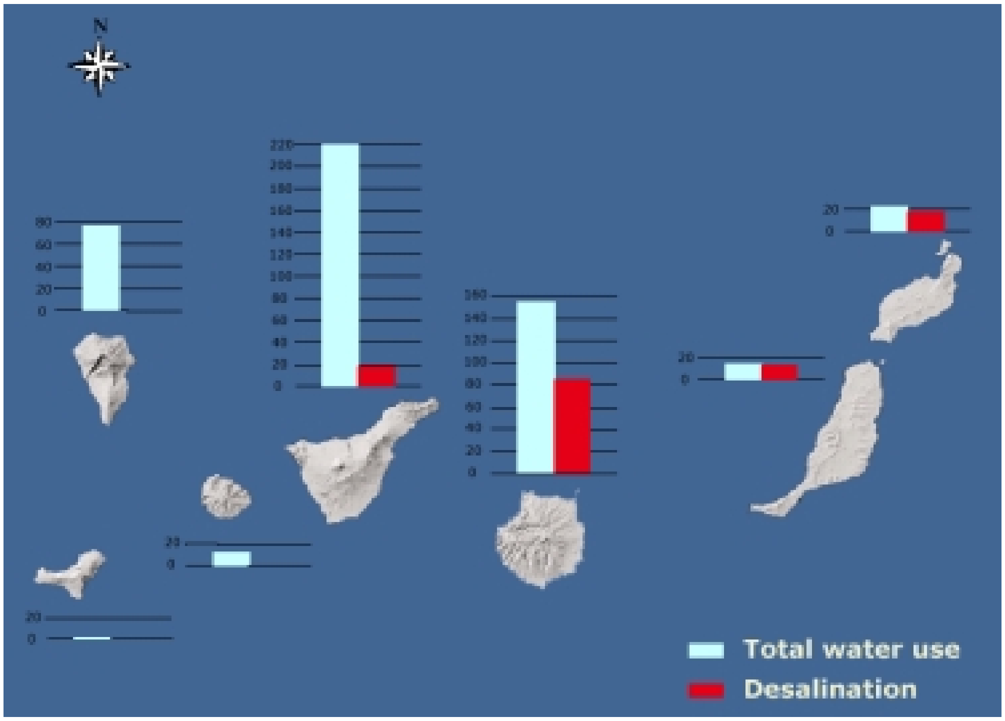

Figure 1. Total water use and desalination in the Canary Islands

Coastal effect of brine discharge and feedwater intake

Coastal effects of brine discharge and feedwater intake are analyzed from field data collected near the coastal area of Maspalomas resort area. The desalination plant object of study produces 25 000 m^3/day of desalinated water with an intake of 42 000 m^3/day feedwater. The brine discharge is 17 000 m^3/day and has a TDS of 90 000 mg/L. It takes place by means of two outfalls that lay parallel and close to each other. Both outfalls are 300 m long. The depth of the brine discharge from the outfalls is 7.3 and 7.5 m respectively. The temperature of the brine is 2ºC higher than ocean temperature.

The feedwater pipeline is 700 m long and lays 600 m east of the brine discharge points. The depth of the intake is 11.3 m. Sixty six water samples were taken in a radius around the brine discharge point covering an area of 1 km^2. Salt concentration and temperature measured at different depths allowed to pictured the isolines of the salt concentration in the area. Results showed that brine discharge quickly dissolves into ocean water. Salinity decreased from +203 % down to +0.04 %, above normal seawater concentration, within 20 meters from the discharge point. Results appear also to indicate that the feedwater intake alters currents from deeper areas, thus causing an increase in salinity around the intake of +0,02% to 0,04%. Visual inspection of the seaweeds communities around the brine outfall and feedwater intake, showed no major impact on the species living in that area.

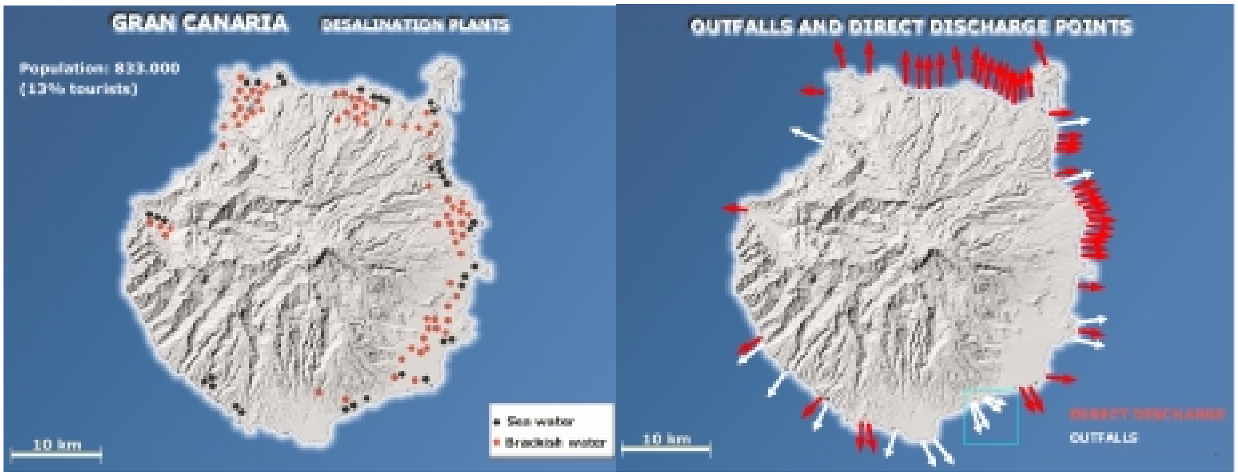

Figure 2. Desalination plants, outfalls and direct discharge points in Gran Canaria island

R&D in renewable energy applied to desalination

Various projects are being carried out by several international research groups at the Canaries Technological Institute (ITC) research station of Pozo Izquierdo in Gran Canaria.

Studies financed by the EU, the Spanish Government and other Institutions are investigating the use of wind and solar energy for desalination purpose.

An example of these studies is the SDAWES project (Seawater desalination by means of an autonomous Wind Energy System) it consist of an off-grid wind farm (two wind generators with 230 kW nominal power each) supplying electricity to three different types of desalination systems: Eight RO modules (each 25 m^3/d); one 250 m^3/d EDR plant (electrodyalisis reversible); and one 50 m^3/day VC plant (vapor compression). Results have allowed to understand the impact of the oscillating wind power on the problems and management techniques to be considered for operating each of this plants. The know-how of this project has allowed to develop a self sustained RO unit (18 m^3/d) driven by a commercial 15 kW wind generator and supported with short-time battery storage.

SODESA is another internationally funded project, based on a solar thermally driven desalination system with corrosion free collectors and a 24 hours per day storage. The installation consists of a distillation system (based on a German patented multieffect humidification process) and driven by low temperature heat produced in a high efficiency non-corrosive collectors, in which seawater is heated directly without using an additional heat exchanger. The system operates at ambient pressure and a temperature of about 80 ºC and includes a hot seawater storage reservoir that reduces thermal inertia losses and allows a 24 h/day distillate production.

Finally, a detailed feasibility study has been submitted to make the small island of El Hierro (269 km^2 and 8 330 inhabitants) self sustainable in water and energy using a combination of wind and hydraulic energy, in combination with RO desalination.

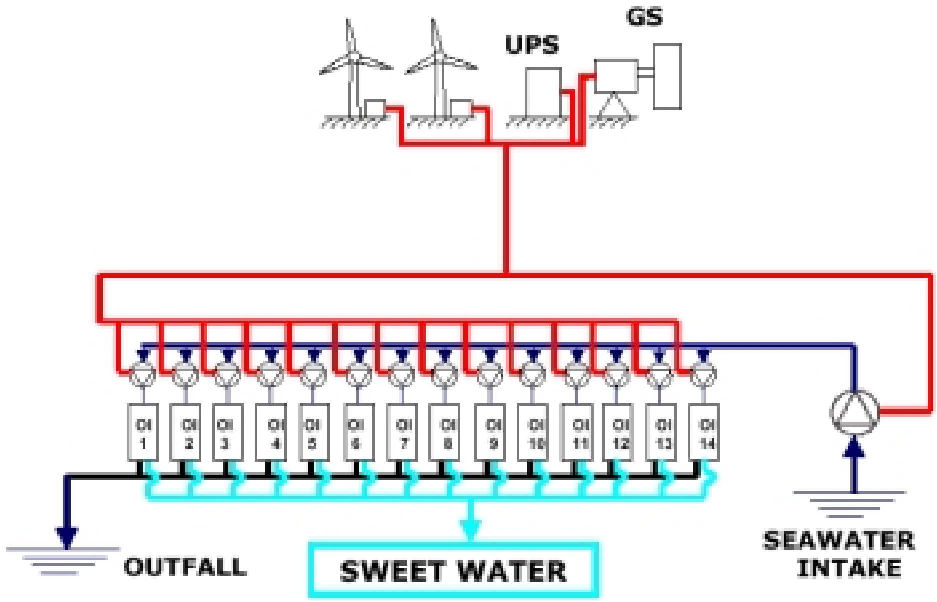

Figure 3. Sizing RO plants for wind energy (CIEA-ITC et al., 1999)

R&D on isobaric chambers to recover pressure from the brine of RO units

Various developments in isobaric chambers have irrupted in the desalination market in the past year allowing for a very efficient energy use in the RO plants. A system, called RO-Kinetics developed in the Canaries by a local company, based on this principle, has shown also very good results. It consists of two loops, that function alternatively, allowing for the continuous transfer of pressure from the brine to the feedwater. The system has been under development for the past two years. Tested on a 250 m^3/day plant has given an energy consumption of 2.3 kW/m^3 desalinated water. Recent developments in its design has make it a robust independent unit, ready to been adapted to RO units of different sizes of up to 3 000 m^3/d.

ENVIROMENTAL PROGRESS IN DOW CHEMICAL IBERICA

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At Dow, protecting people and the environment will be a part of everything we do and every decision we make. Each employee has a responsibility in ensuring that our products and operations meet applicable government or Dow standards, whichever is more stringent. Our goal is to eliminate all injuries, prevent adverse environmental and health impacts, reduce wastes and emissions and promote resource conservation at every stage of the life cycle of our products. We will report our progress and be responsive to the public.

2005 environment, health and safety goals

In 1995, Dow announced Environment, Health and Safety (EHS) goals for the Year 2005. These are voluntary global goals and each geography has adopted them as a part of our commitment to Environmental Progress following the Guiding Principles of Sustainable Development published in early 2000.

These goals are categorized, as follows:

- Responsibility and Accountability. Aggressively promote the Responsible Care ethic by:
- Fully implement Codes of Management Practices globally
- Promote Responsible Care ethic among major associations, customers, suppliers and policy makers
- Incorporate principles of sustainable development and economic efficiency into business strategies

Prevent Environment, Health and Safety Incidents. Significantly improve Dow's EHS performance by reducing:

- Injuries and illness per 200 000 hours by 90 %
- LOPC (leaks, breaks, spills) by 90 %
- Transportation incidents per 10 000 shipments by 90 %
- Process safety incidents by 90 %
- Motor vehicle incidents per 1 million miles by 50 %

Increase Resource Productivity. Further reduce air and water emissions for our operations:

- Priority compounds by 75 %
- Chemical emissions by 50 %
- Amount of waste and waste water generated per pound of production by 50 %
- Reduce energy use per pound of production by 20 %

CASE STUDY 1: Installation of Cyclone Scrubber Systems in our production trains of polyethylene of Tarragona.

This project consisted of the installation of a cyclone scrubber system per train which was designed to avoid molten polymer to be sent to the atmosphere when an emergency shutdown occurs, as well as to reduce the noise level produced as a consequence of the reactor depressurization. The design of the system was performed by MPC, according to a license agreement with Dow. The system includes the following components: blow down vessel, venturi spacer, cyclone separator and vent stack (Fig. 1).

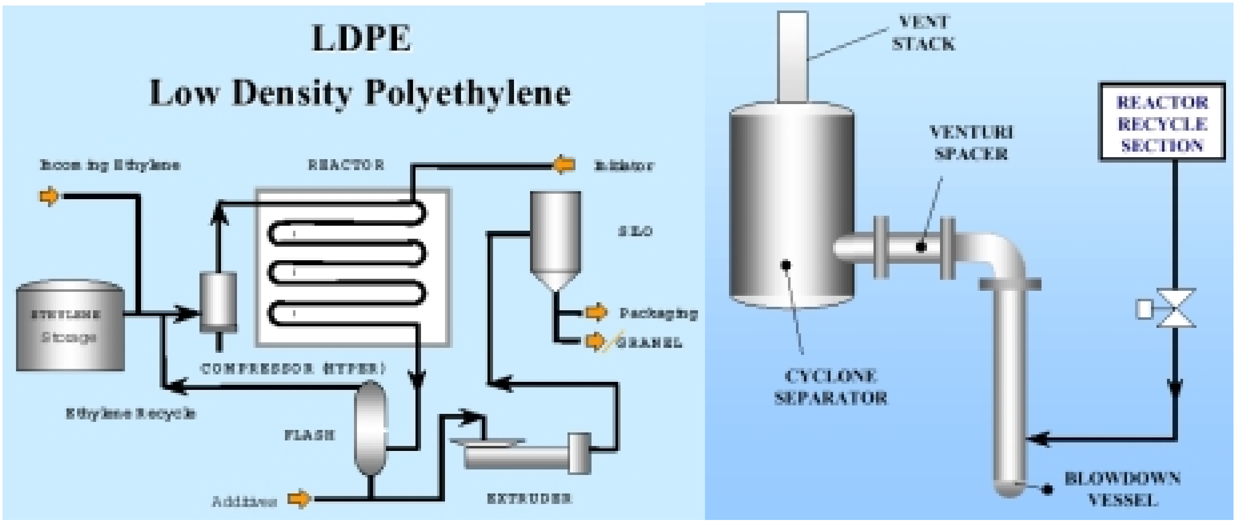

Figure 1. LDPE process and cyclone scrubber system for the reduction of LOPC's events

Blow down vessel receives the gas vented during the shutdown of the plant and high pressure steam is injected simultaneously to avoid potential plugging. Venturi spacer connects the blown down vessel with the cyclone and is designed to allow the installation of a water injection. Finally, cyclone separates the polymer from the gas and the vent stack allows the ethylene gas to be exhausted to the atmosphere.

In addition to this installation, a project team at one of the trains was nominated to reduce the number of above mentioned vents known as loss of primary containment. The team made modifications in the process control program, improved some maintenance practices related to electrical and mechanical items and developed a preventive program for the plant's instrumentation involved in emergency shutdowns. Since then, LOPCs have been drastically reduced and consequently plant reliability has improved.

CASE STUDY 2: Elimination of an existing solar pond used to hold wastewater of high COD content generated in the polyols plant of Tarragona.

For some years, the effluent generated at the polyols plant was conveyed to a solar pond until a strategic plan was established to empty the pond and return about 4000 m^2 of land to its original state.

The plan was carried out in three stages. Firstly, the effluent was minimized by using the MET and following procedures stated in the operating discipline including internal recycle and disposal of wastewater coming from the finishing section in the site boiler. Secondly, two evaporation units were installed in order to reduce, as much as possible, the level of the pond. Thirdly, the sludge mostly polyol and KOH was taken away by an authorized company for final disposal.

At present, the effluent generated is mostly treated internally by using only one evaporation unit and about 10 % is treated externally. The pond has been demolished and the area returned to its original state.

LIGNOSULPHONATES: ENVIRONMENTAL FRIENDLY PRODUCTS FROM A WASTE STREAM

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Black liquors, containing lignin, have been traditionally considered as a strong polluting stream from pulp mills due to their high COD, dark persistent color and foaming tendency.

Kraft pulping introduced the combustion of the lignin to produce energy and recover chemicals. However, a small purge of the digestion liquor, that is usually disposed of, is still needed to avoid increasing concentrations of wood extractives.

Sulphite mills, where lignin combustion is not so easy due to SO_2 emissions, had to seek for a different solution to this polluting stream to comply with stricter regulations.

Borregaard LignoTech, world leader in his business sector, has considered lignin from Spent Sulphite Liquor as a renewable source of chemicals and developed different specific products for several industrial applications.

Lignosulfonate derived products are now worldwide extensively used as concrete plasticizers, providing better workability and increased strength with optimum cost/performance ratio.

In addition to this performance benefits, the use of lignosulfonate concrete admixtures provides an additional environmental aspect in preventing global warming. Cement manufacturing is well known for its contribution to the Greenhouse Effect (0.5-0.8 ton CO_2/ton cement emitted). LignoTech world sales in 2000 to concrete admixtures avoided the emission of about 5 million tons of CO_2 to the atmosphere due to a 5 % reduction in the use of cement.

LignoTech products are also used in many other different areas, such as ceramics, carbon black, particle and gypsum boards, animal feed binders, dye dispersing agents, oil well drillings, etc.

The use of membrane separation processes, have enabled the manufacture of better performing products with a higher added value and also opened a new window in markets not formerly considered.

Different studies have proved the feasibility of lignin as an alternative source for many chemicals currently obtained from petroleum, but this development is still not economically viable.

HYDROGEN ECONOMY AND FUEL CELLS: ENERGY FOR THE FUTURE

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The management of energetic sources and processes will require, in the near future, more efficient and cleaner systems. This challenge should be faced under an innovative point of view, changing the overall scheme of production, transformation, and use of the energy. Most of the fuels used up to now derive from oil as starting material. This aspect has enormous environmental implications in order to accomplish the level requirements in Europe and in the USA. The use of Hydrogen as a clean energy vector, and the application of the Fuel Cells technology, are two of the most proposing issues to be included in the new energetic scheme. Besides, there is a clear tendency for the replacement of oil by natural gas as primary energy source. In the proposed energetic layout discussed in this presentation, natural gas is converted in a first step into hydrogen/syngas. The use, afterwards, of these energetic vectors require catalytic technologies allowing the syngas transformation into clean liquid fuels. These can be used in internal combustion engines (long chain hydrocarbons) or allowing the transformation of the liquid fuel on the vehicle itself (short chain paraffins or methanol) into hydrogen that can be used either by vehicles using fuel cells or internal combustion engines. Another way of envisage the problem is using methanol directly to feed the fuel cell, which requires high efficiency electrocatalysts keeping though the price low. The ensemble of the above-mentioned processes is immerse into a global energetic scheme in which the environmental impact is reduced enormously comparing with the current technologies. Increasing also the process efficiency and overall yield allows keeping costs low and competitive. The development of efficient catalysts together with catalytic technologies plays a very important role in these processes rising the development level of a sustainable energy for the future.

THE USE OF MEMBRANE TECHNOLOGY IN PULP AND PAPER INDUSTRY

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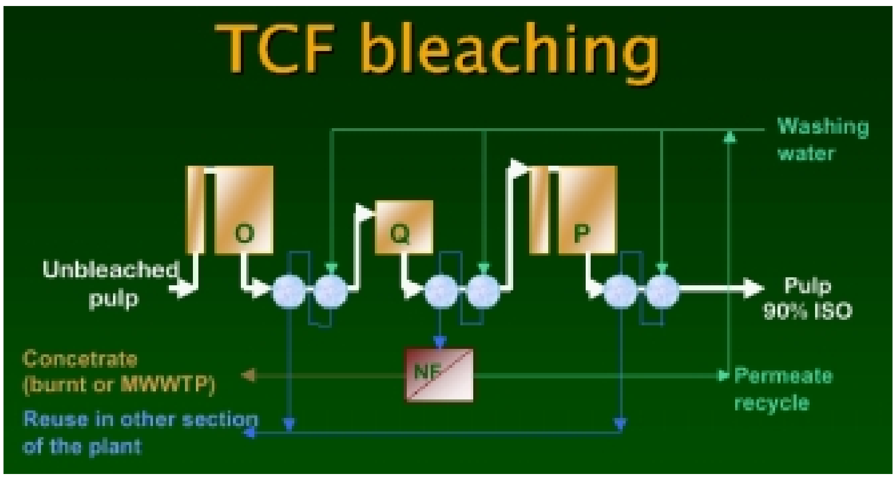
The pulp and paper industry is one of largest consumers of water producing a wide variety of effluents due to the different processes involved.

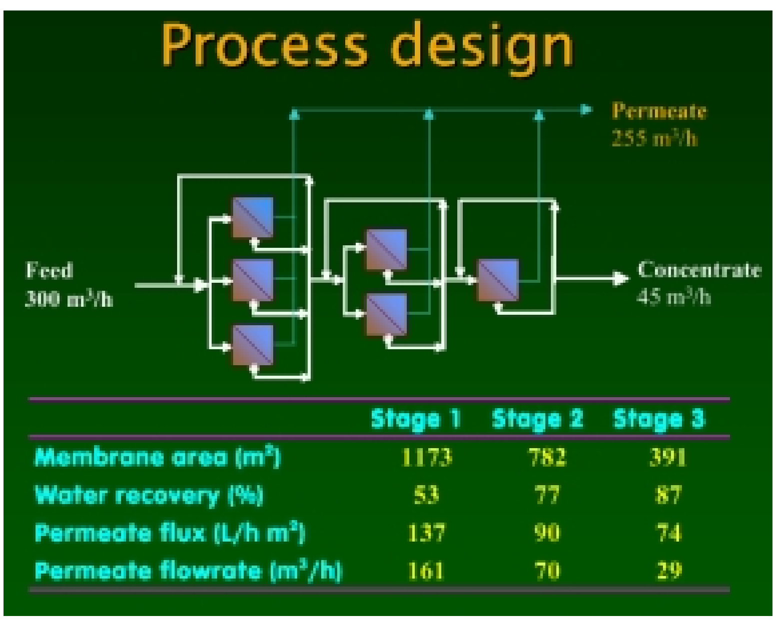
The use of membrane technology at different places in order to provide end-of-pipe treatments or water recycling opportunities has been carried out at the University of Oviedo in cooperation with several industries from Asturias and close regions from the north of Spain.

Ultrafiltration and nanofiltration techniques have been applied to the bleaching effluents from an Elemental Chlorine Free (ECF) bleaching process, as well as the general effluent coming from the neutralization of acid and alkaline streams.

Ultrafiltration of black liquors and Spent sulphite liquors has been performed in order to obtain lignin fractions suitable for higher value- added products.

Nanofiltration of the chelate stage in Total Chlorine Free (TCF) bleaching sequence have been carried out in order to remove Iron and Manganese that are catalysts for the decomposition of the hydrogen peroxide used.





Microfiltration of different streams inside the pulp production process have been carried out in order to eliminate the colloidal organic matter (pitch) in order to increase the quality of the resulting pulp and to recycle the pitch as additional fuel to the main recovery boiler.

Nanofiltration and Reverse Osmosis of feed boiler water have been performed in order to minimize the scaling problems.

ACTIVITIES AND INITIATIVES TO SUPPORT COMPANIES AND BUSINESS SECTORS TO IMPROVE THEIR RELATIONSHIP WITH THE ENVIRONMENT

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The *Centre per a l'Empresa i el Medi Ambient (CEMA)* is a tool of the Ministry of the Environment of the Government of Catalonia at the companies' service, that focuses its attention on promoting Cleaner Production among industry sectors and companies.

In seven years of activity, the CEMA has developed initiatives and activities that have turned out to be a significant support for companies as regards their relation with the environment.

Among these activities, the assessment done to companies in their search for cleaner technologies and experts, the participation in training and diffusion activities, the organization of Cleaner Production diffusion campaigns and the elaboration of studies and publications to promote Cleaner Production are some examples.

Also, CEMA monitors and supervises the carrying out of the Minimization Opportunities Environmental Diagnosis (tool promoted by CEMA that consists on the assessment of an industrial activity to detect potential CP opportunities, and for providing the business with sufficient data for it to orientate its policy towards cleaner practices and technology that are technically and economically viable) and Work Groups (tool aimed at studying the alternatives for the reduction of pollution at source in an industrial sector or geographical area).

Achievements in our aim of promoting Cleaner Production among industry sectors and companies include the following:

- More than 250 Catalan companies have implemented a Minimization Opportunities Environmental Diagnosis. Based on a sample of companies, the identified pollution prevention options by means of the MOED have made possible a 26 % reduction in water consumption, 14 % reduction in consumption of raw materials, a 29 % reduction in waste waters and a 23 % reduction in solid waste generation.

- 8 Work Groups have been carried out, with a participation of a total of 61 companies of the following industry sectors: surface treatment, textile, painting, printing and metallurgy.
- The CEMA has a database of cleaner technologies (with more than 240 inputs) and suppliers of environmental goods and services (with more than 500 inputs) to assess companies. As an example of the assessment done to companies, in 2000, more than 600 consultations were met.
- A pilot diffusion campaign aimed to promote Good Housekeeping practices was carried out with 8 participating companies (in the food, chemical and printing industries and in a hotel) and 75 staff training sessions.
- The CEMA has co-operated in four demo projects to verify, within a technical and economic feasible framework, practices and technologies to prevent pollution applied to companies on a real scale.
- More than 15 studies have been carried out by the CEMA, and 56 files showing examples of waste minimization opportunities implemented in companies and more than 50 articles in technical and economic magazines have been published.
- The CEMA has participated in more then 200 seminars, courses, etc to promote and diffuse the principles and advantages of Cleaner Production.

In addition, due to the Collaboration Agreement signed between the Spanish and Catalan Ministry of the Environment, the CEMA carries out a whole lot of activities within the framework of the United Nations Mediterranean Action Plan as Regional Activity Centre for Cleaner Production (RAC/CP) and it also participates in International Projects and develops co-operation activities in Latin America with the objective of further promoting Cleaner Production.

The initial scenario encountered when dealing with companies was characterized by a *passive*-do nothing- approach that became *reactive*: adopting corrective actions in front of legislative pressure- and then *active*: adopting corrective actions before having sanctions without considering the environment as a change opportunity.

The CEMA aims at achieving a step further: the *proactive* approach, where the environmental management orientated towards CP is integrated in the global company management and the company adopts a continuous improvement strategy.

In acknowledgement of its aims and proactive initiatives with companies, the CEMA has been awarded the “III Prize Company and Environment” within the “Best Public Support Initiative for Companies” by the most-widely spread newspaper in Spain, *Expansión*, the *Garrigues-Arthur Andersen* consulting group and the *Institut d’Estudis Superiors de l’Empresa (IESE)*, given on October 3rd by the Minister of the Environment.

TREATMENT OF OIL-CONTAINING WASTEWATERS USING CLEAN TECHNOLOGIES

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Oil-in-water emulsions are found in several industrial operations involving two inmiscible fluids. Some of them are desirable (*e.g.* as final products in the cosmetics and food industry), but in some cases they are undesirable, as in liquid-liquid extraction operations, removal of rubber from latex, cleaning bilge water from ships, cold rolling mill effluents, etc. Spent cutting-oil emulsions are one of the largest volumes of oily wastewaters resulting from metalworking industries, specially in steel cold rolling operations. Water-based lubricants and cutting oils have replaced some petroleum-based products in the metalworking industry, as a result of their higher performance. These fluids, containing mainly emulsified oil and surfactants which allow emulsion formation and stabilization when mixed with water, become less effective after use because of their thermal degradation and contamination by substances in suspension, and therefore they must be replaced periodically. The spent oil must be treated before its disposal, due to their detrimental effects on aquatic life and their interference with conventional wastewater treatment processes. Several physicochemical methods for the treatment of spent oils, such as settling, chemical treatment, dissolved air flotation, centrifugation and membrane techniques have been investigated.

The aim of this work is the design and construction of a modular pilot plant for the treatment of different water-based coolants and oily wastewaters generated in metalworking processes and steel cold rolling operations. A suitable spent cutting-oils treatment consists of three basic steps: primary, secondary and tertiary treatment, as shown in Fig.1.

The design should allow the combination of several treatment operations, depending on the nature of the stream to be treated. The entire process should be automatically controlled using a specific computer software. Different treatments will be considered depending on the nature of the oily waste emulsion, such as coagulation/flocculation, centrifugation, ultrafiltration and sorption processes. With these principles in mind a modular plant was built and its schematic diagram is shown in Fig. 2.

The main advantage of this plant is its versatility, allowing the combination of the aforementioned treatments, being a feasible waste management alternative from an economic point of view. This might lead to a better control of this kind of wastes and a better reuse of water, in the case of large industrial plants, with the resulting environmental and economic improvements.

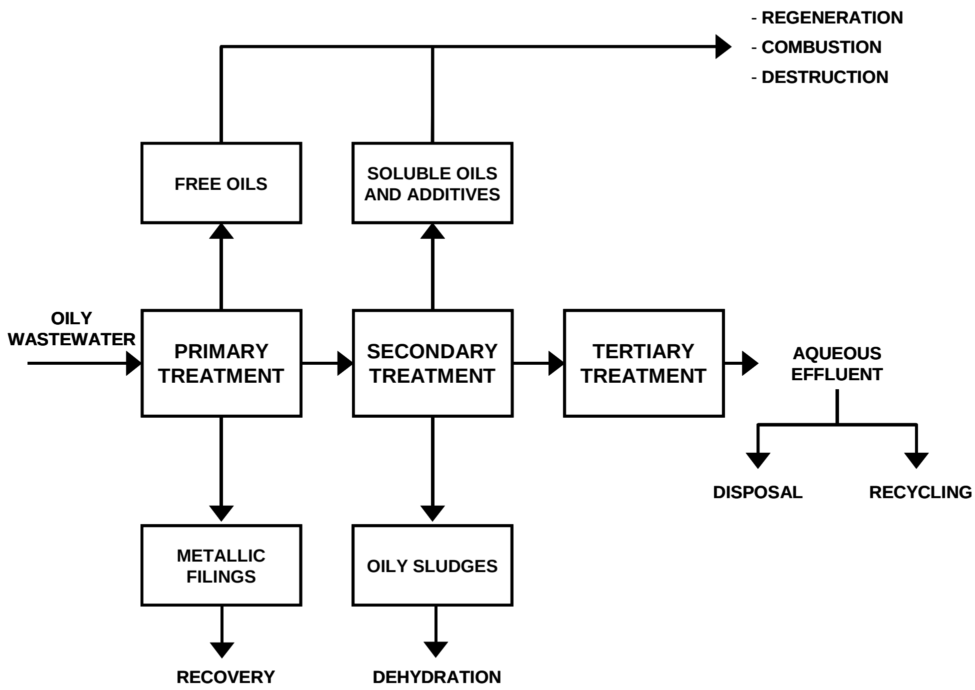

Figure 1. General process for the treatment of spent cutting oils

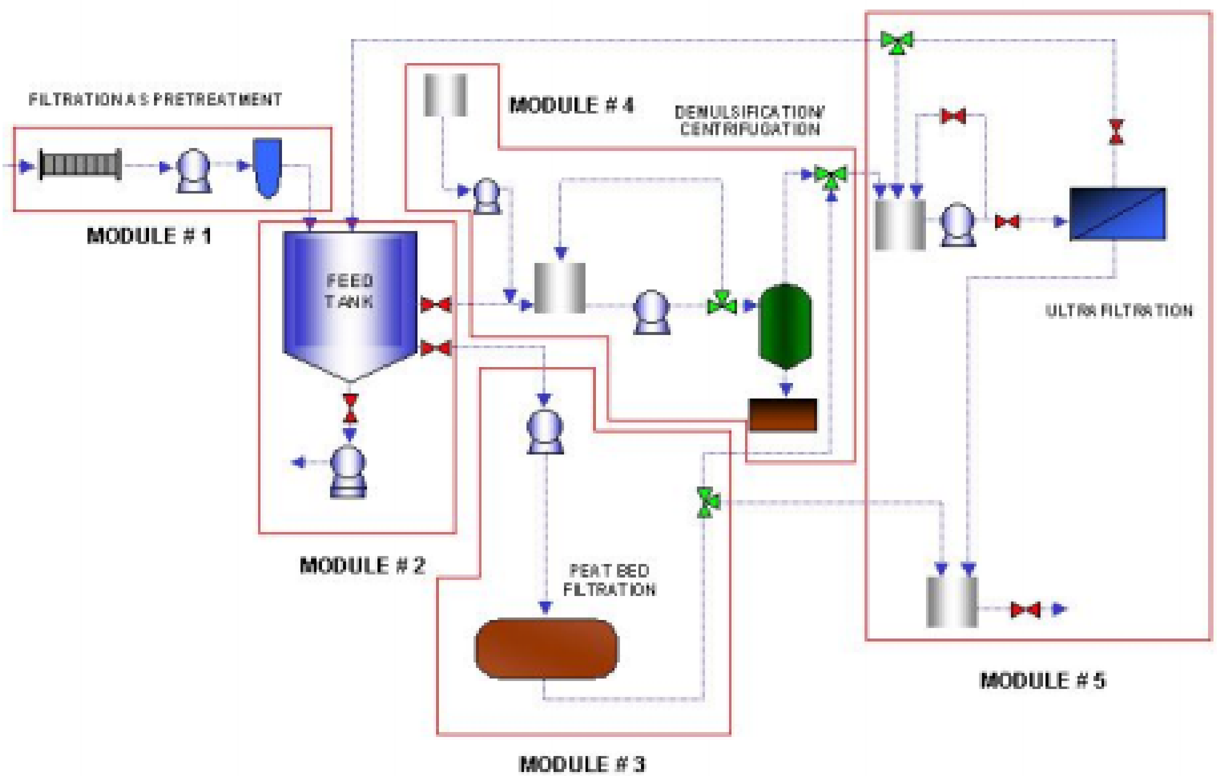

Figure 2. Schematic diagram of the modular pilot plant for the treatment of oil-containing wastewaters

THE NEW LEGISLATION ON ENVIRONMENTAL QUALITY AND CLEAN PRODUCTION

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A brief summary will be reported on the recent legislation (Spanish and European) regarding environmental quality and its relation to the European Directive 96/61/EC on Integrated Prevention and Control of Environmental Pollution (IPPC).

NON-FERROUS METALLURGICAL WASTES: FUTURE REQUIREMENTS

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The deterioration of environmental quality, which began when man first collected into villages and utilized fire, has existed as a serious problem under the even-increasing impact of exponentially increasing population and of industrializing society. As a consequence of that there are an uncontrolled and increasing generation of waste, resulting a environmental contamination of air, water, soil and food.

The challenge of our society is to find the equilibrium between development and environmental protection, in order to reach a *sustainable development*: the way of satisfying the needs of the modern society without an irreversible damage of the natural resources. Two tools could be used:

- Best Available Techniques (BAT): the latest stage of development (state of the art), of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste.
- Best Environmental Practice (BEP): the application of the most appropriate combination of environmental control measures and strategies.

The aim of this research is the application of these tools for the treatment of wastes generated in non-ferrous (pyrometallurgical, hydrometallurgical and melting) metallurgical operations:

- Waste for recovery: those that can be recycled or reused either in the same plant where they were generated, or in other plant in a different location.

- Waste for disposal: those that, with the present state of the art, cannot be recycled or reused. This type of residue can be generated by a primary metallurgical process or as a consequence of waste recycling.

The Principle: *The environment is an additional responsibility of the company that must be an integral part of the company's management.*

HOW TO MAKE CARBOCHEMISTRY COMPATIBLE WITH THE ENVIRONMENT

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It is very well known that carbochemistry is considered worldwide as a very pollutant activity. In this paper it is shown how Industrial Química del Nalón, S.A. manages its plants and environmental policy to meet the clean processes criteria.

Industrial Química del Nalón, S.A. was founded in 1943 with the explicit vocation of developing, manufacturing and marketing chemical products, with a especial orientation towards coal and its derivatives.

Located in Asturias (Spain), its industrial activity started in Trubia with the distillation of coal tar and the manufacture of the inorganic salts of potassium (nitrate and permanganate), lead and calcium, continuing in 1945 with the manufacture of foundry coke and the treatment of by-products, obtaining ammonium sulphate and benzol. With the passing of time, numerous economic cycles and technological changes have taken place that have meant the reorganisation of its different industrial activities and work centres.

Currently, the company develops its corporate activity along two lines of business: High specification carbochemical products and coke, being the most important private distiller of tar and one of the leading producers of foundry coke in Southern Europe.

Its centres of production in Asturias, based in Trubia (Carbochemicals Division) and Langreo (Coke Division), have logistics installations in the ports of Avilés (Spain), Szczecin (Poland) and Marseille (France). Its head office is located in Oviedo (Spain).

Its business trajectory is founded under the attributes of corporate solvency, development of its own technological processes, respect for the environment, differential quality in products and services, safety and health of its employees, collaborators and the surrounding environment.

The development of these attributes of business excellence has led Industrial Química del Nalón, S.A. to the technological forefront in the field of Carbochemicals and to be the first European company to certify its Quality and Environmental Management system on the basis of the requirements of the ISO 9002 and ISO 14001 standards, respectively.

Environmental policy

"In the development of industrial activity, behavior that affects the safety and health of our employees, neighbours, customers and the community in general, and respect for the environment, will be of priority interest in business decisions".

Industrial Química del Nalón, S.A., considers respect for the environment as an strategic, competitive factor and a permanent and priority element of its activities.

The basic directives of this policy with respect to the environment are: Compliance with the legal regulations in force, training and information for employees, information to the authorities, neighbours and the community in general, collaboration with the competent Administrations and Institutions (voluntary agreements), continuous improvement of processes and products, minimizing and anticipating negative environmental effects, rational use of natural resources, prevention and control of pollution by means of documented procedures and, collaboration with and information to suppliers and customers.

During the period 1993-2000, a series of actions have been taken with the aim of integrating the Environment into the productive processes and management of the Company, not only as a legal requirement, but also as a factor of competitiveness that enables the conquest of new markets, an improvement in sales and the consolidation of the Company's leadership.

The aim is, therefore, to adequately manage the environmental aspects of our activities in order to transform the Environment into a differential, strategic factor, which will itself increase external credibility with respect to customers, the Administration and our environs.

The fundamental lines of action have been: Direct (environmental correction) or indirect (new plants) investment plans and the development of an environmental management system in accordance with the requirements of the ISO-14001 standard.

Investments are oriented towards reducing atmospheric emissions, residues and noise, as well as towards new facilities. These investments have meant:

- The employment of the best available technologies in the new plants built
- The definitive authorisation on the part of the Administration for the emission of liquid effluents at the sites at Trubia and Ciaño
- A substantial reduction in specific energy consumptions and, therefore, in the corresponding emissions
- The substitution of fuels with a high sulfur content (2.5 %) by others with a lower content (0.7 %), with the subsequent reduction in SO_2 emissions
- Recovery and re-utilization of carbon residues from surface water ponds

- Rational use of natural resources (water and energy)
- Elimination of un-controlled emissions

An example of a clean, carbochemical process: production of refined naphtalene

Technical grade naphthalene (96.5 %) is obtained directly from tar distillation. Its major contaminants are sulfur (present as thionaphthene) and phenols that have boiling points too close to naphthalene.

For catalytic processes, sulfur compounds can poison the catalyst, decreasing its operating life and efficiency. For domestic, colorants, and leather applications phenols make the colour unstable.

By a selective catalytic hydro treatment sulfur (present at a level of 5 000 ppm) is transformed into hydrogen sulfide that is very easy to remove. Final sulfur content could be as low as 2 ppm. Hydrogen sulfide is washed with sodium hydroxide to produce a sodium sulfide solution suitable for water treatment plants as a precipitant for heavy metals, leather pre-treatment and mineral flotation.

Before the hydro treatment stage, naphthalene is hot washed with a sodium hydroxide solution to extract phenols, producing a sodium phenolate solution that is marketed for phenols recovery. These phenols are used as biocides and for fine chemicals manufacturing in general.

Other suitable processes for naphthalene purification involve dynamic or static crystallization stages that yield a heavy contaminated oil. There is no application in the market for such a kind of oil due to its high sulphur content. The only possibility is to use it as a fuel, but it makes SO_2 emissions to be out of the control limits.

Hydro treatment processes in combination with liquid and gas/liquid extraction allows Industrial Química del Nalón to produce the highest purity naphthalene in the market (>99.97 %) with absolutely no effluents and no solid residues.

TREATMENT OF PHENOLIC WASTEWATER IN THE SALICYLIC ACID MANUFACTURING PROCESS

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Many chemical processes generate wastewater streams containing high concentrations of organic materials. Phenols are one of these materials and are difficult to be treated by conventional methods. Wastewater of salicylic acid manufacturing process has phenol and several phenolic compounds, a pH of 2 and a high concentration of sulfate ions, which must be decreased before being pumped to the local wastewater treatment plant.

In this work, it is studied the elimination of the phenol content in the effluent by means of LOPROX process (Low Pressure Oxidation). This is a wet air oxidation method, developed by Bayer AG. It is also studied the reduction of sulfate concentration by means of recovery as a calcium sulfate after precipitation with calcium hydroxide. Calcium sulfate can be reused by cement industry.

Experimental

This study has been carried out in LOPROX plant of Química Farmacéutica Bayer, S. A (La Felguera Factory). Figure 1 shows a flow diagram of LOPROX plant.

Phenolic wastewater is pumped (12 – 14 bar) to first column (B2a), after being preheated with the outlet stream in heat exchangers (W1.1, W1.2 and W1.3). In the first column it is also introduced a stoichiometric amount of oxygen through an injector (I_A). There, fine bubbles are formed, improving the contact between gas and liquid. Oxidation is an exothermic reaction, but it is necessary to heat with steam in order to reach 140 ºC.

Column B2a works completely full and the outlet stream is pumped to the second column (B2b), where an additional amount of oxygen is added (Injector I_B). This column has a level measuring device (B2c). The outlet liquid stream flows from the bottom of B2c to storage vessel. The outlet gas is released in the top of column, where is also controlled the pressure of the system at 10 bar.

Oxidation reaction is catalyzed by Fe^{++}. Catalyst is prepared from $FeSO_4x7H_2O$ and is pumped to B2a Column. Following reactions occur:

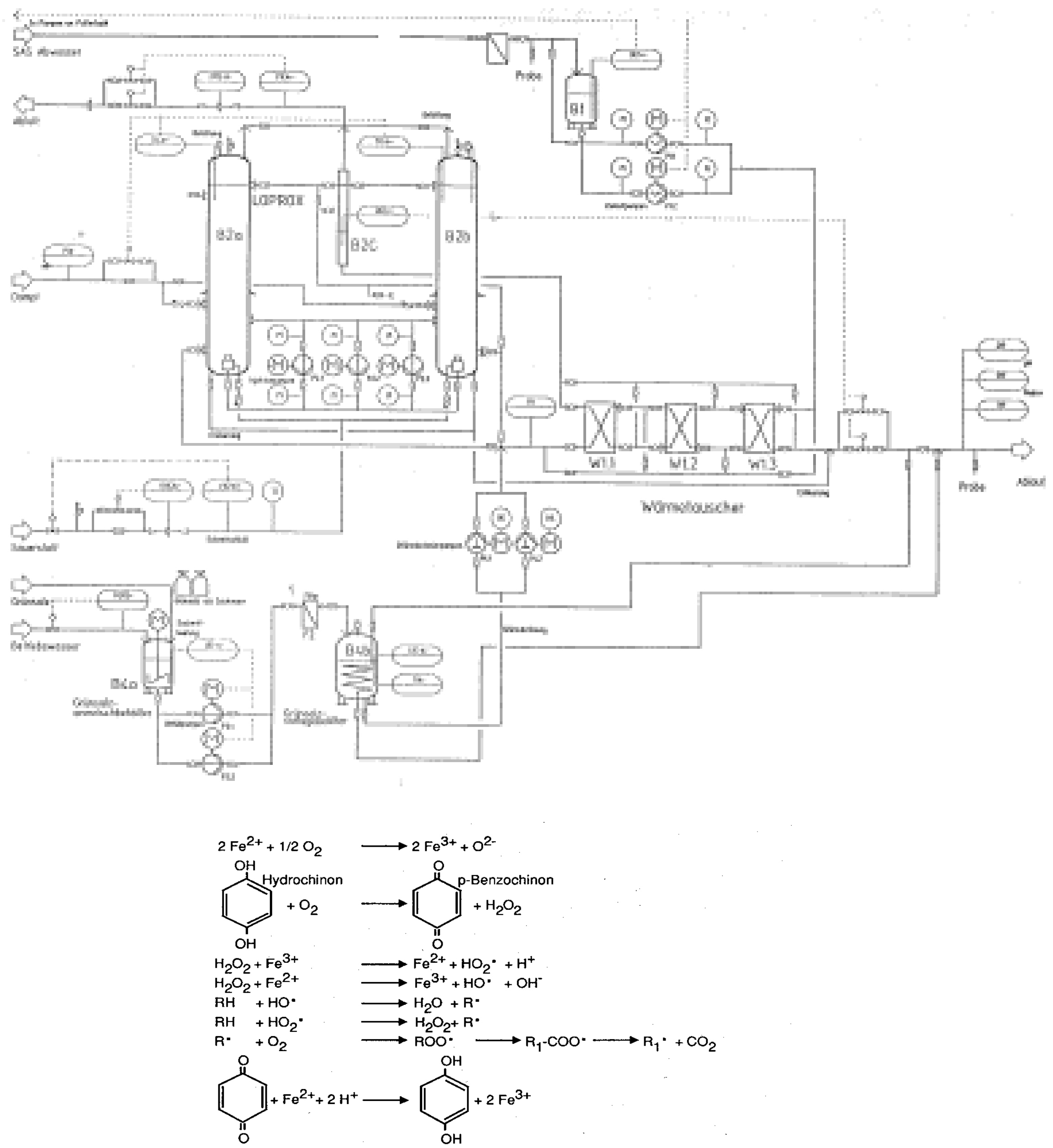


Figure 1. Flow diagram of LOPROX process

Results and discussion

Figure 2 shows the inlet phenol concentration and the outlet phenol concentration for a certain number of samples. The final concentration of phenol is always less than 2 ppm. The COD reduction can be observed in Figure 3. The outlet wastewater (after LOPROX treatment) has a ratio COD:BOD < 2:1. Therefore, it is a biodegradable stream. The reduction of salicylic acid (S.A) concentration is over 95 %.

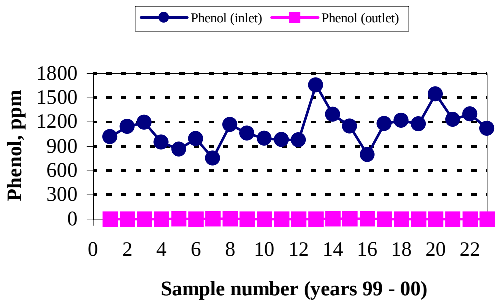


Figure 2. Degradation of phenol

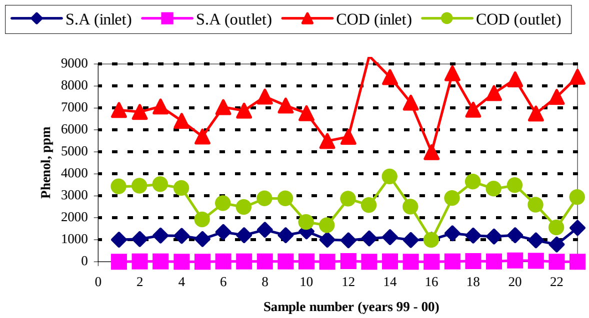


Figure 3. Salicylic acid and COD evolution

The outlet stream of LOPROX process has a pH of 2. Neutralisation can be carried out with calcium hydroxide. Depending on the final pH, a certain amount of calcium sulphate can be precipitated. Figure 4 shows that for a pH of 7, a decrease of 70 % of the initial sulphate concentration (50 g/l) can be obtained, which means 63 g/l of precipitated calcium sulphate (gypsum, $CaSO_4x2H_2O$). This material can be used in cement industry.

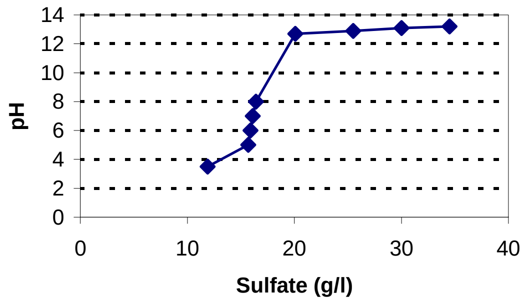


Figure 4. Sulphate concentration vs pH

Conclusions

LOPROX procedure is an adequate method for the elimination of phenol content of the phenolic wastewater stream, generated in manufacture of salicylic acid. There is also a strong decrease in COD. Neutralisation of the outlet stream, under appropriate conditions, produce calcium sulphate as a recovered material.

References

1. Otto Horak, Chem.-Ing.-Tech. 62, 7, 555-557 (1990)
2. Bayer AG, Geschäftsbereich SN, Umweltschutztechnik D-5090 Leverkusen

NATO FIELD TRIPS

The traditional field trip was held on Wednesday, May 9, 2001. Meeting participants were given a tour of the Department of Chemical Engineering at the University of Oviedo. Several laboratories and pilot plant facility were included in the tour. The field trip continued with a visit to the DuPont Company facility. A tour of the NOMEX production facility and its ecosystem restoration projects highlighted the visit. The technical tours were interrupted to visit the scenic coast of Asturias and its impressive cliffs. The field trip concluded with a tour of a cider production plant in Villaviciosa.

DuPont Asturias Plant

The DuPont plant in Asturias began its activities in 1993. Currently the plant produces Tetrahydrofuran (THF), Nomex® brand fiber and Sontara® spunlaced products. Nomex is a fiber used in fabrics for apparel, ranging to men's suits.

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.

The NATO/CCMS Pilot Study group at DuPont plant

Valle, Ballina y Fernández

The Valle, Ballina y Fernández is one of the oldest cider companies in Spain. It is located on the edge of the town of Villaviciosa, one and a half hour drive from Oviedo. This company makes cider from the Asturian apples, although it needs to purchase apples from other regions in Spain, and even from some European countries. The company uses modern technology, including several membrane processes, and it was the industrial partner in a European project, in order to study the depectination of apple using enzymes and the recovery of aroma compounds by pervaporation.

The main cider brand produced in the company is "Sidra El Gaitero" which is very popular in Spain, South America and Florida (US), because of the large number of Cuban population in that state.

At the end of the tour the participants had a chance to taste several kinds of cider and a variety of Asturian food specialties.

The group tasting the Asturian "Sidra El Gaitero" at the Valle, Ballina y Fernández company

OPEN FORUM ON CLEAN PRODUCTS AND PROCESSES AND FUTURE DIRECTION OF THE PILOT STUDY

The closing session of the meeting was held on Friday, May 11, 2001. Several issues were discussed, but most discussion centered around the creation on new, multi-national pilot projects that would move the pilot study into new areas. Several new pilot projects were identified for initiation during the coming year. The following projects will begin during 2001:

- Cleaner Production Approaches in Industrial Parks/Industrial Symbiosis/Industrial Ecology - Denmark, Hungary, Israel, Poland and Turkey

- Hybrid Membrane Applications for Cleaner Production - Denmark, Italy, Poland, Russia and Spain

- Sustainable Indicators/Bench Marking - Germany, Hungary, Lithuania and Norway

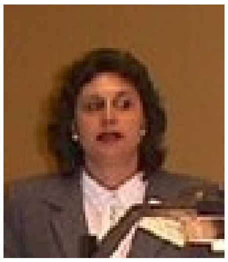
- Cleaner Production Tools Application - Greece, Hungary, Lithuania and United States

The final order of business was the selection of the host country for the 2002 meeting. After nominations and discussions, the delegates unanimously selected Lithuania to host next year's meeting. Professor Jurgis Staniskis, Institute of Environmental Engineering, Kaunas University of Technology, will host the pilot study's next meeting. The meeting will be held in Vilnius, Lithuania, on May 12-16, 2002.

APPENDIX I

LIST OF DELEGATES AND PARTICIPANTS

BULGARIA



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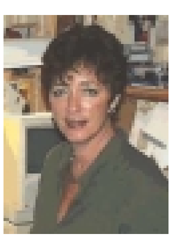

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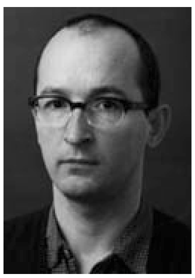

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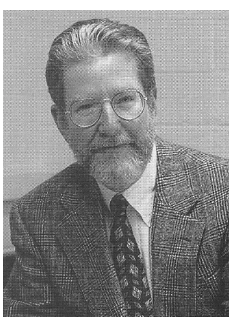

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APPENDIX II

PROGRAM FOR THE MEETING IN OVIEDO, SPAIN 2001

SUNDAY, MAY 6, 2001

18:00 Participants gather in the Hotel Ramiro I

18:30 Reception, registration and get-together at Hotel Ramiro I

Welcome:

Dr. Subhas K. Sikdar, Pilot Study Director
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Prof. José Coca
Department of Chemical and Environmental Engineering
University of Oviedo
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20:00 Departure for Dinner (Bus)
20:30 Dinner at Latores Restaurant

MONDAY, MAY 7, 2001

08:15 Breakfast-Hotel Ramiro I

09:00 Welcome-Oviedo Auditorium***. R. Gutiérrez Palacios, General Director of Universities, Higher Education and Research and J. A. Vázquez, Rector of the University of Oviedo***

09:15 Meeting Introduction. ***S. K. Sikdar, Pilot Study Director***

09:30 Introduction round of country delegates and participants

09:45 Overview of Meeting Agenda, Field Visits and Events. ***D. Murray, Pilot Study Co-Director***

10:00 Break - Coffee/Tea

10:30 Presentation (30 min)
- HOW GREEN ARE GREEN PLASTICS?. ***T. Gerngross (USA)***

11:00 Pilot Project Updates (20 min each)
- TOOLS FOR POLLUTION PREVENTION. ***S. K. Sikdar (USA)***
- ENVIRONMENTAL IMPACTS OF HC EMISSIONS IN LIFE CYCLE ANALYSIS OF GASOLINE BLENDING OPTIONS. ***T. M. Mata, R. L. Smith, D. M. Young, and C. A. V. Costa (Portugal-USA)***
- PILOT STUDY WEB SITE. ***D. Murray***

12:00 Departure for visit of the Down Town (walking distance from the conference centre)
12:45 Welcome by Oviedo Major ***Gabino de Lorenzo***. Oviedo City Hall.
13:00 Lunch
14:40 Arrival-Oviedo Auditorium

15:00 Tour de Table Presentations (15 min each)
- PROGRESS AND NEW PERSPECTIVES ON INTEGRATED MEMBRANE OPERATIONS FOR SUSTAINABLE INDUSTRIAL GROWTH. ***E. Drioli and M. Romano (Italy)***
- FOSTERING RESOURCE EFFICIENCY THROUGH NETWORKING AND CONVENIENT INFORMATION ACCESS – GERMANY’S CLEARINGHOUSE COOPERATIVES ON CLEANER PRODUCTION IN THE WORLD WIDE WEB (WWW). ***H. Pohle (Germany)***

- CLEANER PRODUCTION STRATEGY AND TACTICS. ***W. Zadorsky (Ukraine)***
- CERAMIC MEMBRANES IN CLEAN PROCESSES IN RUSSIA. ***G. G. Kagramanov (Russia)***
- TOWARDS RESPONSIBLE INDUSTRIAL DISPOSAL IN SPAIN. ***J. Coca (Spain)***

16:30	Break - Coffee/Tea
17:00	Poster and computer presentations

Posters:

- CLEANER PRODUCTION OF FARMERS AND FOOD PRODUCERS IN THE CZECH REPUBLIC. ***A. Christianová, F. Božek, J. Dvořák and A. Komár (Czech Republic)***
- ENVIRONMENTAL IMPACTS OF HC EMISSIONS IN LIFE CYCLE ANALYSIS OF GASOLINE BLENDING OPTIONS. ***T. M. Mata, R. L. Smith, D. M. Young, and C. A. V. Costa (Portugal-USA)***
- CERAMIC MEMBRANES IN CLEAN PROCESSES IN RUSSIA. ***G. G. Kagramanov (Russia)***
- TOOLS AND METHODS FOR CLEAN TECHNOLOGIES. ***W. Zadorsky (Ukraine)***
- ENVIRONMENTAL BIOTECHNOLOGY IN THE QUESTOR CENTRE. ***J. Swindall (UK)***
- THE QUEEN'S UNIVERSITY IONIC LIQUID (QUILL) RESEARCH CENTRE. ***J. Swindall (UK)***
- CATALYTIC TREATMENT OF GASEOUS EMISSIONS FROM COKE OVENS. ***L. S. Escandón, M. A. G. Hevia, J. R. Paredes, P. Hurtado, S. Ordoñez and F. V. Díez (Spain)***
- OPERATION OF AN EXPERIMENTAL PLANT FOR TREATMENT OF COKE OVEN WASTEWATER INSIDE A SIDERULGICAL COMPANY. ***M. Díaz, A. Gutiérrez and A. Rancaño (Spain)***

Computer demonstrations:

- NATO CCMS CLEAN PRODUCTS AND PROCESSES WEB SITE U.S. EPA – LCACCESS. ***D. Murray (USA)***
- ENVIRONMENTALLY FRIENDLY TECHNOLOGIES DATABASE. ***W. Zadorsky (Ukraine)***
- ON-LINE VIRTUAL CLEANER TECHNOLOGY INCUBATOR. ***W. Zadorsky (Ukraine)***
- FOSTERING RESOURCE EFFICIENCY THROUGH NETWORKING AND CONVENIENT INFORMATION ACCESS – GERMANY'S CLEARINGHOUSE COOPERATIVES ON CLEANER PRODUCTION IN THE WORLD WIDE WEB (WWW). ***H. Pohle (Germany)***

18:00	Sessions are over
20:30	Participants gather in the Hotel Ramiro I
21:00	Dinner at Auditorium Restaurant

TUESDAY, MAY 8, 2001	
08:15	Breakfast-Hotel Ramiro I
09:00	Presentation (30 min) • PROGRAMS OF THE U.S. NATIONAL SCIENCE FOUNDATION: AN OVERVIEW. ***T. W. Chapman (USA)***
09:30	Tour de Table Presentations (15 min each) • CLEANER CHEMICAL PROCESSES BY USING PINCH ANALYSIS AND MATHEMATICAL PROGRAMMING. ***P. Glavic (Slovenia)*** • POLLUTION PREVENTION IN ROMANIA - OPTIMISTIC PERSPECTIVE. ***V. Harceag (Romania)*** • CLEANER TECHNOLOGIES AND INDUSTRIAL ECOLOGY. ***A. M. Fet (Norway)*** • THE ROLE OF ORGANISATIONAL FACTORS IN THE. IMPLEMENTATION OF CLEANER PRODUCTION MEASURES. ***G. Zilahy (Hungary)***
10:30	Break - Coffee/Tea
11:00	Pilot Project Updates (20 min each) • POLICY STATEMENT ON DEVELOPING GOODS AND SERVICES WHICH MEET PEOPLE'S NEEDS BUT INVOLVE THE USE OF FEWER NATURAL RESOURCES IN MOLDOVA. ***S. Galitchi (Moldova)*** • NEW PROCESSES AND MATERIALS FOR ENVIRONMENTALLY BENIGN SEMICONDUCTOR MANUFACTURING. ***F. Shadman (USA)*** • PILOT PROJECT ON EVALUATION OF CLEAN PRODUCTS AND PROCESSES IN MEMBER COUNTRIES. ***M. Overcash (USA)***
12:00	Tour de Table Presentations (15 min each) • (NATIONAL PROGRAM FOR CLEANER PRODUCTION. ***D. Sucharovova (Czech Republic)***) NOT PRESENT • CYCLE OF REUSING INDUSTRIAL DUSTS FOR WASTEWATER TREATMENT AND CONSTRUCTION. ***A. Doniec (Poland)*** • CASE STUDIES OF INDUSTRIAL WASTEWATER TREATMENT IN CONSTRUCTED WETLANDS. ***S. Martins Dias (Portugal)*** • CLEANER PRODUCTION AND PRODUCTS IN LITHUANIA. ***J. Staniskis (Lithuania)***
13:00	Lunch at Auditorium Restaurant
14:30	Tour de Table Presentations (15 min each) • AGRIFOOD INDUSTRY IN BULGARIA. ***S. Tepavitcharova (Bulgary)*** • CEVI, THE DANISH CENTRE FOR INDUSTRIAL WATER MANAGEMENT. ***H. Wenzel (Denmark)*** • THE STATE OF PLAY OF THE IPPC/96/61/EC DIRECTIVE: THE CASE OF FOOD INDUSTRIES WITH SPECIAL REFERENCE TO GREECE. ***G. Gallios (Greece)*** • ***TITLE NOT AVAILABLE. C. Forgacs (Israel)***
15:30	University-Industry Co-operation Presentations • QUESTOR/QUILL UPDATE. ***J. Swindall (UK)***
16:00	Break - Coffee/Tea
16:30	University-Industry Co-operation Presentations • UNIVERSITY/INDUSTRY RELATIONS IN SPAIN. ***J. Coca (Spain)***
17:00	Sessions are over. Departure for Visit (Bus)
17:30	Pre-Romanesque Asturian Art in Oviedo (approx. 1 hour) Return to the Hotel
20:30	Participants gather in the Hotel Ramiro I. Departure for Dinner (walking distance)
21:00	Dinner at Hotel Principado

WEDNESDAY, MAY 9, 2001 - FIELD TRIP

08:00	Breakfast-Hotel Ramiro I
08:45	Boarding the bus
09:00	Visit to the Department of Chemical Engineering. University of Oviedo
10:00	Departure (Bus)
10:30	Visit to the Du Pont Company
12:30	Departure (Bus)
13:00	Lunch at La Mina Restaurant
15:00	Departure (Bus)
16:00	Visit to a cider production site: Villaviciosa
19:00	Return to Oviedo (approx. 30 min)
20:30	Participants gather in the Hotel Ramiro I. Departure for Dinner (Bus)
21:00	"Espicha" at "Llagar el Carbayón" Hotel La Gruta

THURSDAY, MAY 10, 2001

SPECIAL TOPIC DAY
ENVIRONMENTAL CHALLENGES IN THE PROCESS INDUSTRIES

08:15	Breakfast-Hotel Ramiro I
09:00	Welcome to the Special Topic Day. ***J. Coca and H. Sastre, Counselor of Environment of the Principality of Asturias***
09:10	Morning Conferences I (30 min each) • PRINCIPALITY OF ASTURIAS: ENVIRONMENTAL POLICY. *T. Coca and H. Sastre, Government of the Principality of Asturias (Spain)* • ADVANCES IN ENVIRONMENTAL ASPECTS OF DESALINATION: THE CANARY ISLANDS EXPERIENCE. ***M. Hernández-Suárez, Canary Islands Water Center (Spain)*** • ENVIROMENTAL PROGRESS IN DOW CHEMICAL IBERICA. ***J. Bessa, Responsible Care Leader, Dow Ibérica, S.A. (Spain)***
10:40	Break - Coffee/Tea
11:00	Morning Conferences II (30 min each) • LIGNOSULPHONATES: ENVIRONMENTAL FRIENDLY PRODUCTS FROM A WASTE STREAM***. M. Rodríguez, Lignotech Ibérica, S.A. (Spain)*** • HYDROGEN ECONOMY AND FUEL CELLS: ENERGY FOR THE FUTURE. ***M. A. Peña, Head of Department of Structure and Reactivity, Institute of Catalysis and Petrochemistry, CSIC (Spain)*** • THE USE OF MEMBRANE TECHNOLOGY IN PULP AND PAPER INDUSTRY. ***D. Gómez, S. Luque, J. R. Álvarez, J. Coca Department of Chemical & Environmental Engineering. University of Oviedo (Spain)***
13:00	Lunch at Auditorium Restaurant
14:30	Afternoon Conferences I (30 min each) • ACTIVITIES AND INITIATIVES TO SUPPORT COMPANIES AND BUSINESS SECTORS TO IMPROVE THEIR RELATIONSHIP WITH THE ENVIRONMENT. ***B. Gallego, Ministry of Environment of the Government of Catalonia (Spain)*** • TREATMENT OF OIL-CONTAINING WASTEWATERS USING CLEAN TECHNOLOGIES. ***J. M. Benito, G. Ríos, E. Ortea, E. Fernández, A. Cambiella, C. Pazos and J. Coca. Department of Chemical & Environmental Engineering. University of Oviedo (Spain)*** • THE NEW LEGISLATION ON ENVIRONMENTAL QUALITY AND CLEAN PRODUCTION. ***J. Martínez Ministry of Environment (Spain)***
16:00	Break - Coffee/Tea
17:30	Afternoon Conferences II (30 min each) • NON-FERROUS METALLURGICAL WASTES: FUTURE REQUIREMENTS. ***J. M. Poncet, Asturiana de Zinc, S.A. (Spain)*** • HOW TO MAKE CARBOCHEMISTRY COMPATIBLE WITH ENVIRONMENT. ***J. J. Fernández and I. Trelles, Department of R&D, Industrial Química del Nalón, S.A. (Spain)*** • TREATMENT OF PHENOLIC WASTEWATERS IN THE SALICYLIC ACID MANUFACTURING PROCESS. ***M. F. Ortega, A. Cagigas, J. Alvarez, Química Farmacéutica Bayer, S.A. (Spain)***
18:00	Sessions are over
20:30	Participants gather in the Hotel Ramiro I. Departure for Dinner (Bus)
21:00	Dinner at Latores Restaurant (Oviedo)

FRIDAY, MAY 11, 2001

08:15	Breakfast-Hotel Ramiro I
09:00	New Pilot Projects
09:30	Discussion. Moderator: ***D. Murray, Pilot Study Co-Director***
10:30	Break - Coffee/Tea
11:00	Future Directions for the Pilot Study. ***D. Murray, Pilot Study Co-Director*** • Topics and Focus for Next Meeting • Host Country and Dates for 2002 Meeting
12:30	Meeting Wrap Up. ***S. K. Sikdar, Pilot Study Director***
13:00	Lunch at Auditorium Restaurant

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

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