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**FINAL REPORT
Of
NATO/SPS Pilot Study on
Clean Products and Processes (Phase I
and II)**

By

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Foreword

The U. S. Environmental Protection Agency (USEPA) is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, USEPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threaten human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by: developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

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Sally Gutierrez, Director
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Abstract

Early in 1998 the NATO Committee for Challenges to Modern Society (SPS) (Science for Peace and Security) approved the Pilot Study on *Clean Products and Processes* for an initial period of five years. The pilot was to provide a forum for member country representatives to discuss the problems and opportunities of cleaner production. The pilot did not sponsor projects nor try to create policies. The main aim was to examine tools, extant and in development stages, for assessing, preventing and reducing pollution.

While western nations have made significant gains in cleaning up the environment through regulations, enforcement, public disclosure requirements, and emerging new technologies, an increased knowledge of health and environmental impacts of pollutants has heightened the need for doing more on cleaner products and processes. Environmental concerns have accompanied the accelerated industrialization occurring throughout the developing world. The proposed objective of the NATO SPS Pilot Study on clean products and processes was to facilitate further gains in pollution prevention, waste minimization, design for the environment, and sustainability. It was anticipated that the free exchange of knowledge, experience, data, and models would foster innovations, collaborations, and technology transfer on improving the environment worldwide.

In the United States, the following government programs have helped to drive cleaner manufacturing:

Industries of the Future (Department of Energy)

Green Lights, Project Excel, Green Chemistry Challenge, Common Sense Initiatives (U.S. Environmental Protection Agency)

Strategic Environmental Research & Development Program (Department of Defense)

Advanced Technology Program (U.S. Department of Commerce)

American industry has responded with its own cleaner manufacturing initiatives such as *Responsible Care* (Chemical Manufacturers Associations), *Vision 2020* (the chemical industry), *ISO 14000*, and *Pollution Prevention*. The public has also heightened the need for cleaner manufacturing through environmental activism, litigation, protests, and awareness programs. With the more recent focus on sustainable development and sustainability, cleaner production has taken a more holistic approach that considered societal impacts of products and processes in addition to economic and environmental ones.

Citing published sources, air emissions such as nitrogen oxide, volatile organic compounds, particulate matter, sulfur dioxide, and carbon monoxide, are shown to have decreased significantly since 1970 (accompanying significant environmental regulations) in the U.S. and are expected to continue the downward trend. Similarly, since the advent of the Toxics Release Inventory (where American companies must publicly report annual emissions levels), reported releases have continued to decline. These two broad trends demonstrate the efficacy of a three-pronged approach to ensuring cleaner manufacturing: government regulations, industry cooperation (in response to economic incentives), and public interest. Through this pilot-provided forum for sharing our experiences with tools for cleaner products and processes, it was thought we could educate ourselves with the latest technical knowledge that would benefit each country.

In evaluating the success of the Pilot Study, we used several metrics:

1. Have we succeeded in elevating the knowledge base of the representatives of countries, especially those emerging economies in transition from the former Soviet block of countries?
2. Have we succeeded in focusing on the most important environmental and sustainability issues confronting every country in the world?
3. Have we succeeded in fostering friendly and collaborative relationships among the country delegates?
4. And, have we succeeded in planting the seed for current and future, organic collaborations among nations on substantive projects?

The report will show that we have succeeded immeasurably on all counts, especially when we consider the investment made in the pilot only went to defraying the costs of holding annual meetings. We are thankful to the NATO SPS for approving this pilot study, and to the U.S. Environmental Protection Agency for providing supplemental funding for each of the eleven annual meetings at eleven different locations.

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Acknowledgements

Subhas Sikdar and Dan Murray are indebted to the tremendous cooperation they received from the delegates in making this Pilot a success. Special thanks are due to the host directors of the annual meetings in various countries. The hosts volunteered to undertake the enormous task of organizing the meetings and raised supplemental funds from local sources to defray some of the costs. We are also thankful to all the industry leaders who welcomed the delegates and showed us around in the facilities and openly discussed about the their cleaner production events. Lastly, without the generous support from NATO SPS and the National Risk Management Research Laboratory of the USEPA the Pilot could not be sustained successfully for a decade.

CHAPTER 1

Background of the pilot study

Cleaner production is a significant contribution to the idea of sustainable development. The Pilot Study therefore treated cleaner production as indistinguishable from sustainable technologies.

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. The goal of sustainable development will, in the manufacturing sectors, be achieved by a combination of several methods. One method is improved housekeeping in process plants leading to large reductions of emissions and discharges of pollutants. Another method is significant modifications of existing process technologies through the application of sound science and advanced technologies. Yet another method is totally new process designs that are environmentally preferable, made possible by using tools for life cycle assessment (LCA) and environmental impacts. An effective pilot study should have far-reaching influence on future developments in three important areas. First, we must address the issue of measuring cleanliness through devising environmental and sustainability indicators (called analytical tools or computer software). Second, we must examine advanced techniques for achieving specific goals in selected industry sectors, such as power generation, textile, pulp and paper, leather tanning, metal finishing and mining. Third, we must examine advanced techniques for cleaner product designs. Additionally an effective web-based dissemination method needs to be established to share the knowledge among academia, government agencies, and industries of all nations.

With the backdrop of sustainability in manufacturing processes, Clean Products and Processes (in two phases) was an attempt to lay the foundation of such an effective pilot study. This pilot first met in Cincinnati in 1998 with representatives from 14 member countries in attendance. The subsequent annual meetings took place in Belfast, Northern Ireland; Copenhagen, Denmark; Oviedo, Spain; Vilnius, Lithuania; Cetraro, Italy; Budapest, Hungary; Alesund, Norway; Istanbul, Turkey; Porto, Portugal; and Berlin, Germany, respectively. The membership in the pilot in the interim increased to 30 countries. The following table provides the dates and the names of the host directors of the annual meetings.

Year	Venue	Host Director
1998	Cincinnati, OH, USA	Dr. Subhas Sikdar, National Risk Management Research Laboratory, US EPA, Cincinnati, OH
1999	Belfast, Northern Ireland, UK	Prof. Jim Swindall, Queen's University of Belfast, Belfast
2000	Copenhagen, Denmark	Prof. Henrik Wenzel, Denmark Technological University, Lyngby*
2001	Oviedo, Spain	Prof. Jose Coca, University of Oviedo, Oviedo
2002	Vilnius, Lithuania	Prof. Jurgis Staniskis, Kaunas University of Technology, Kaunas
2003	Cetraro, Italy	Prof. Enrico Drioli, University of Calabria, Rende
2004	Budapest, Hungary	Prof. Gyula Zilahy, University of Economic Sciences and Public Administration, Budapest
2005	Alesund, Norway	Prof. Annik Fet, Norwegian University of Science and Technology, Trondheim
2006	Istanbul, Turkey	Prof. Aysel Atimtay, Middle East Technical University, Ankara
2007	Porto, Portugal	Dr. Teresa Mata and Dr. Antonio Martins, University of Porto, Porto

2008	Berlin, Germany	Dr. Horst Pohle, Federal Environmental Agency, Berlin
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*currently with Int. of Chem Eng, Biotechnology and Environmental Technology, Odense M, Denmark

Our goal of creating an effective forum for exchanging new ideas, knowledge, and methods for achieving cleaner products and processes was achieved. The Pilot Study was launched at a time when the environmental impacts of industry and its products, and the depletion of natural resources were just beginning to be appreciated. Additionally, in the span of the first five years, only a few technology sectors could be examined. The need for keeping this forum alive for free exchange of ideas for continued sharing among the member nations was evident. Phase II was needed to conduct the unfinished business of dealing with the exploding developments in cleaner production technologies and methods and of addressing some of the more important industry sectors.

Pilot Member Countries and Delegates

Country	Latest Representative	Comments/first representative
USA	Subhas Sikdar	1998-08, Director of Pilot
USA	Dan Murray	1998-08, Co-Director of Pilot
Belgium	Carlo VandeCastele and Chantal Block	2004-08
Bulgaria	Stefka Tepavicharova	Charter member/Christo Balarew
Canada	Alex Omelchenko	Charter member/Anthony Kosteltz
Croatia	Ksenija Vitale	2004-08
Czech Republic	Ales Komar and Frantisek Bozek	Charter member/Dagmar Sucharovova (deceased)
Denmark	Henrik Wenzel	Charter member, host, 2000
Egypt	Kamal Ewida	2003-08, Deceased, 2007
Georgia	Khatuna Gogaladze	2004-08
Germany	Horst Pohle	2000-08, Host, 2008
Greece	George Gallios	1999-08
Hungary	Gyula Zilahy	Charter member/Lajos Nebb-Csorba , host, 2004
Israel	David Wolf and Chaim Forgacs	2000-20008
Italy	Enrico Drioli	2000-08, Host, 2003
Lithuania	Jurgis Staniskis	Charter member/Gerda Sviezauskaite, host, 2002
Moldova	Alexandru Stratulat	Charter member/Sergiu Galitchi
Norway	Annik Fet	2003-08, Host, 2005
Poland	Andrzej Doniec	1999-08
Portugal	Teresa Mata and Antonio Martins	Charter member/Susete Dias, host, 2007
Romania	Viorel Harceag	1999-08
Russia	Georgi Kagramanov	2001-08
Slovak Republic	Mirka Vaclavikova	Charter member/Lubomir

		Kusnir
Slovenia	Peter Glavic	2003-08
Spain	Jose Coca Prado	2000-2008, Host, 2001
Turkey	Aysel Atimtay	Charter member/Akin Geveci, host, 2006
UK	Jim Swindall	Charter member, host, 1999
Ukraine	William Zadorsky	1999-08
Japan	Ryuchiro Kurane	1998-1999
South Africa	Chris Buckley	2003
Sweden	Tomas Rydberg	2000, 2002
Switzerland	Christiane Maillefer	1998
Chile	Maria Elena Torres	1998

Specific Goals of the Pilot Study

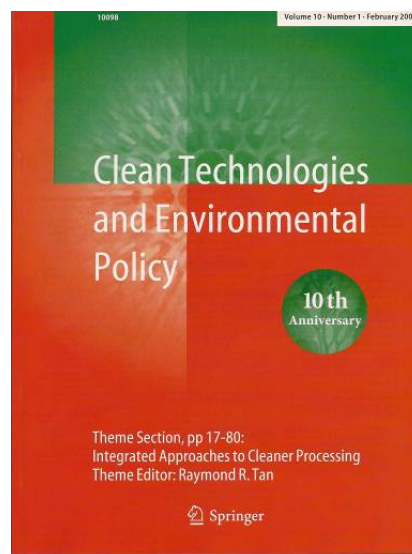
The success and popularity of this Pilot Study was evident in the gradual increase in the number of NATO and partner countries joining during its duration. Expressions of support for the pilot and for continuing this study in Phase II were overwhelming among the delegates. Outside of Europe and North America, even countries such as Japan, Chile, and South Africa joined the Pilot Study, at least for a time. Among the Mediterranean Dialogue countries, delegates from Israel and Egypt were in consistent attendance. The number and nature of products and spin-off activities that this study has engendered is a clear sign of the impact the pilot has achieved. The detailed list of spin-off benefits from this study is provided at the end of this report.

The Pilot Study emphasized on the following items:

- We planned to focus on exchanging and developing the best science to support the ideas of eco-efficiency and sustainability indicators. These yardsticks will be used throughout the world to identify technologies and products that are environmentally friendly. We wanted to use this Pilot Study to promote harmonization of the indicators for universal use.
- We planned to examine the state-of-the-art developments in certain key emerging and existing technology areas, such as biofuels, nanotechnology, process syntheses, etc. These priority areas were identified by the members of the pilot.
- We planned to construct a dissemination mechanism for the results of the pilot activities and related developments elsewhere. It was deemed that such comprehensive databases would be useful to those around the world. US EPA pledged to develop a web-based portal and link it to the NATO SPS home page.
- We planned to stimulate collaboration among member countries in solving common problems. To a great extent, care would be taken to see that in each collaborative study at least one partner country was involved.

The Pilot Study was comprised of three areas: (a) tools for assessment of pollution prevention, sustainability, and cleaner products and processes, (b) cleaner production methods selected in industry sectors, and (c) electronic dissemination of cleaner production knowledge, products, and processes (with tutorials and examples).

- a. **Decision Tools:** Decision-making tools for pollution prevention, sustainable practices, and product designs was a continuous focus. These tools are important because they integrate environmental solutions, life cycle concepts, process engineering, economics, product design methods, and new assessment and measurement methods. Most of these tools are computer-based and amenable to dissemination through the web. Particular concepts that underlie these tools are life cycle assessment (LCA), sustainability metrics, eco-efficiency indicators, process simulation and design, material substitution, and environmental impact assessment.
- b. **Specific industry sectors:** The pilot members identified some industry sectors as important. In each year we planned to focus on one of these for in-depth discussion and assessment. The priority sectors are metal finishing, food/agricultural, pulp and paper, leather tanning, printing, and electronic industries. In addition, the pilot members decided to hold a one-day in-depth analysis of the major technological trends that impact cleaner production. These symposia were typically held with speakers from both the pilot membership and invited from outside. Several very successful symposia were held. Selected papers from these symposia were published as a collection in the peer-reviewed journal, *Clean Technologies and Environmental Policy*, published by Springer-Verlag, Heidelberg, Germany.
- c. **Information dissemination:** An electronic portal was to be created by EPA, and linked to the NATO SPS website. This portal would host reports of ongoing work of the pilot, as well as by individual members.



Peer-reviewed journal in which many of the papers from the one-day symposia were published.

Assessment of Success

Throughout the Pilot Study, in the wrap up sessions at the end of each meeting, we examined how the pilot was doing. We deliberated on what was being accomplished, and what improvements needed to be made. Based on these discussions, we can confidently state the following conclusions:

1. A significant task of the Pilot Study, i.e. creating spin-off projects among countries, resulting from the availability of this platform for exchange of ideas was very successful. This is evidenced by the number of collaborations that naturally happened.
2. The forum led to understanding problems, opportunities and the state of technological prowess of the member countries. After the two phases, we have learned a great deal of the state-of-the-art thinking on technological issues, thus elevating knowledge about cleaner and sustainable production. Through the years, because of the general discussions, and particularly because of the one-day topical symposia, each of us was made aware of the state-of-the-art of emerging technological issues of relevance to sustainability. This has been a great achievement.
3. Each annual meeting featured visits to exemplary industrial sites that practice cleaner production. These visits widened our understanding of real world manufacturing issues.
4. The annual gathering fostered sincere friendships among the delegates leading to a better understanding among the communities of nations.
5. The members of the Pilot Study were supposed to represent the respective nations. However, since these are busy professionals, collecting representative information of national scale was not always easy. Thus a forum such as this one, by its very nature, was limited in scope on this front.

CHAPTER 2

Summaries of National Meetings

The following accounts provide details of the proceedings of the annual meetings

1998 Annual Meeting **March 23-26, 1998** **Cincinnati, Ohio, United States of America**

The first meeting 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. This Pilot Study was established to create an international forum where current trends, developments, and know-how in cleaner technologies, and in tools for measuring their cleanliness could be discussed, debated and shared. It was hoped that, through its annual meetings, productive interactions could be stimulated among national experts, with the expected benefits of effective technology transfer.



Group photo from the Inaugural Meeting in Cincinnati in 1998

In this first meeting, it was explained that this NATO CCMS Pilot Study was approved by NATO and that the study was comprised of representatives from interested countries that meet once a year to discuss issues important to the field of clean products and processes. It was stressed that pilot studies do not sponsor research projects or try to create policy; they are a forum for sharing information – in this case – technology and tools to assess, prevent and reduce pollution.

While western nations have made significant gains in cleaning up the environment through regulations, enforcement, public disclosure requirements, and emerging new technologies, an increased knowledge of health and environmental impacts of pollutants has heightened the need for cleaner products and processes. Environmental concerns have accompanied the accelerated industrialization occurring throughout the developing world. The objective of this Pilot Study was to facilitate further gains in pollution prevention, waste minimization, and design for the

environment. It was anticipated that the free exchange of knowledge, experience, data and models would foster innovations, collaborations and technology transfer on improving the environment worldwide.

The first meeting of this pilot study was comprised of the following components:

- guest lectures to address selected clean technology issues
- a report on the U.S. Department of Energy's Industries of the Future program
- tour-de-table presentations by participating nations
- technical site visits
- consideration of which industry sectors should be focused on for projects
- discussion on future meetings

It was proposed that measures of success for this Pilot Study should be based on those from other pilot studies and should include:

- group input and interaction
- spin-off from pilot studies – looking at specific issues which provide and exchange of information among groups
- keeping the same national representatives throughout the pilot study timeframe
- development of an industrial process or helpful government policy as a result of the Pilot Study.

During the meeting, agreement was reached that “tools” would remain a high priority focus throughout the life of the pilot study. A list of priority industrial sectors to be focused on was as follows:

- textiles
- organic chemicals, including pharmaceuticals
- energy production
- pulp and paper
- food
- leather
- machinery
- metal finishing
- metal production
- agricultural

Delegates from 14 nations participated in this first Pilot Study meeting. The countries represented were Bulgaria, Portugal, Moldova, Turkey, Canada, Slovak Republic, Switzerland, Hungary, Czech Republic, Lithuania, United Kingdom, Chile, Denmark, and the United States. At the conclusion of the meeting the delegates accepted the invitation of the United Kingdom to host the 1999 annual meeting at Queen's University in Belfast, Northern Ireland.

**1999 Annual Meeting
March 21-25, 1999
Belfast, Northern Ireland, United Kingdom**



Visit of the delegates to a DuPont facility in Belfast

The 2nd meeting of this Pilot Study, held in Belfast, Northern Ireland, United Kingdom, on March 21-25, 1999, capitalized on the momentum of the first year of the study. The meeting focused on the progress made on several pilot projects that were being implemented by the delegates of the participating nations. The meeting was hosted by Professor Jim Swindall, Director, Queen's University Environmental Science and Technology Research Center, Queen's University, Belfast. The meeting was sponsored by NATO CCMS, U.S. EPA and Queen's University, Belfast. Delegates and participants represented 18 nations including, Bulgaria, Canada, Czech Republic, Denmark, Germany, Hungary, Israel, Italy, Japan, Lithuania, Poland, Portugal, Romania, Slovak Republic, Turkey, Ukraine, United Kingdom and the United States.

The opening session included remarks from Dr. Subhas Sikdar, Pilot Study Director, that emphasized that the main goal of the study was for nations to work together to avoid environmental pollution through information exchange. The delegates were welcomed to Belfast on behalf of the Queen's University Environmental Science and Technology Research Centre, by Professor Adrian Long, Dean of Engineering at Queen's University in Belfast.

The meeting included many technical and programmatic presentations from delegates and specially invited speakers including,

- Dan Murray (USA): Goals and objectives of the NATO CCMS pilot study on clean products and processes.
- Russell Dunn (USA): Process integration technology for clean processes.
- Kenneth Seddon (United Kingdom): Ionic liquids - neoteric solvents research and industrial applications.
- Louis Divone (USA): U.S. industrial energy efficiency research, including a focus on metal casting.
- Peter Carter (United Kingdom): Clean products and processes from the trade union perspective.

- Paul Hamley (United Kingdom): Use of supercritical carbon dioxide in clean production.
- G.V. Huston (United Kingdom): Liquid effluent treatment research and development at BNFL Sellafield.
- Jim Swindall (United Kingdom): An overview of the QUESTOR research centre.
- Matthias Finkbeiner and Horst Pohle (Germany): Life-cycle engineering as a tool to develop and promote clean products and processes and the cleaner production internet system in Germany.
- Adrian Steenkamer (Canada): Canadian cleaner production activities.
- Susete Martins Dias (Portugal): Reed-bed treatment of wastewater from chemical industries.
- Nigel Carr (United Kingdom): Promoting good practice in Northern Ireland and Great Britain - help for sustainable waste management through waste reduction and clean technology.
- Jurgis Staniskis (Lithuania): Cleaner production in Lithuania.
- William Zadorsky (Ukraine): A Ukrainian's version of a systems approach to sustainable development in environmentally damaged areas - cleaner production and industrial symbiosis as major ways to pollution prevention.
- Ryuichiro Kurane (Japan): R&D for clean products and processes in Japan.
- Andrzej Doniec (Poland): Cleaner production and pollution prevention in Polish industry.
- Subhas Sikdar (USA): Preventing pollution - the U.S. approach.
- Akin Geveci (Turkey): Report on the status of clean products and processes in Turkey.
- Chaim Forgacs (Israel): Clean products and processes in Israel.
- Kristof Kozak (Hungary): Clean processes and pollution prevention in Hungary.
- Enrico Drioli (Italy): Activities at the research institute on membranes and modeling of chemical reactions related to clean products and processes.
- Dagmar Sucharovova (Czech Republic): Cleaner production in the Czech Republic.
- Henrik Wenzel (Denmark): The Danish center for industrial water management.
- Stefka Tepavitcharova (Bulgaria): Utilization of the waste brines from the sea salt production.
- Viorel Harceag (Romania): Some steps to pollution prevention.
- Lubomir Kusnir (Slovak Republic): Clean processes and products in the Slovak Republic.
- Henrik Wenzel (Denmark): Danish product-oriented measures in the textile industry.
- Subhas Sikdar (USA): Tools for pollution prevention.
- Farhang Shadman (USA): Water conservation and recycling in semiconductor industry - control of organic contamination and biofouling in UPW systems.
- Akin Geveci (Turkey): Conducting research and development aimed at developing cleaner production technologies to assist textile industry to manufacture in compliance with international standards.
- Adrian Steenkamer (Canada): Cleaner production using intelligent systems in the pulp and paper industry.
- Michael Overcash (USA): Pollution prevention development and utilization - a history to 2000.
- Aysel Atimtay (Turkey): Cleaner energy production with combined cycle systems.
- Dan Murray (USA): Pollution prevention technology transfer at the U.S. EPA.

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

Dr. Subhas Sikdar facilitated an open forum at the end of the meeting where delegates discussed the structure of the pilot study and plans for the future. At the end of the discussions, the delegates chose to hold the 2000 annual meeting in Copenhagen, Denmark, in May.

**2000 Annual Meeting
May 7-12, 2000
Copenhagen, Denmark**

The 3rd meeting of this 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 was hosted by Associate Professor Henrik Wenzel, Denmark Technical University, Institute for Product Development. Participants in this meeting represented the following 19 countries: Bulgaria, Czech Republic, Denmark, Greece, Israel, Italy, Moldova, The Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, Turkey, Ukraine, United Kingdom, and the United States.



Group photo of delegates in Copenhagen

The meeting began on Sunday with an opening reception and get-together at the Danish Design Center. Delegates were greeted to the meeting by Dr. Subhas Sikdar, Pilot Study Director; Mr. Dan Murray, Pilot Study Co-Director; and the meeting host, Associate Professor Henrik Wenzel.

The meeting featured tour-de-table presentations from national delegates which covered a wide range of related technical topics including,

- Jose Coca (Spain): Membrane and membrane-based hybrid processes in cleaner production.
- George Gallios (Greece): Status of IPPC and LCA in Greece.
- Jim Swindall (United Kingdom): UK support for clean products and processes.
- Henrik Wenzel (Denmark): The role and goals of the Danish textile stakeholder panel within the product oriented environmental initiative.
- Andrzej Doniec (Poland): Selected activities on clean products and processes in Poland.
- Dagmar Sucharovova (Czech Republic): Czech national cleaner production program.
- Lubomir Kusnir (Slovak Republic): Clean products and processes, Slovak Republic.
- Sergiu Galitchi (Moldova): Energy supply, consumption and saving potentials.
- Chaim Forgacs (Israel): Standardization as an incentive - water subsidiaries - hazardous waste.
- Enrico Drioli (Italy): Research for clean production in progress.
- Akin Geveci (Turkey): Report on the status of cleaner products and processes in Turkey.
- Susete Martins Dias (Portugal): The Portuguese textile industry - clean technology and waste management.
- Stefka Tepavitcharova (Bulgaria): Clean environment and its sustainable development and water resources in Bulgaria.
- William Zadorsky (Ukraine): Cleaner production strategy and tactics, definition, tools and methods based on systematic approach to sustainable product development for systematic reduction of environmental loads (ecologizing or “ecologization”).
- Viorel Harceag (Romania): One more step to pollution prevention.
- Subhas Sikdar (USA): Sustainable development - new challenges to environmental R&D.

Several pilot project updates were presented during the meeting. These included,

- Subhas Sikdar (USA): Pollution prevention tools.
- Jim Swindall and Mike Larkin (United Kingdom): Detection and control of microbioccontamination in ultrapure water processes.
- Michael Overcash (USA): Review of programs in cleaner production.
- Nilgun Kiran (Turkey): Cleaner production implementation for wet processes of cotton textiles.
- Aysel Atimtay (Turkey): Cleaner energy production with combined cycle systems.
- Henrik Wenzel (Denmark): The Danish center for industrial water management - an update.
- Dan Murray (USA): International exchange and dissemination of information on clean products and processes - within the Pilot Study and to industry and the public.

Several specially invited speakers made presentations:

- Leo Alting (Denmark): Engineering for sustainable development - an obligatory skill of the future engineer.
- Enrico Drioli (Italy): Membranes in process intensification and cleaner production.
- Vladimir Dobes (Czech Republic): Approaches to cleaner production in economies in transition - the results and perspectives of the cleaner production centers.
- Rafiqul Gani and Peter Harper (Denmark): Computer-aided molecular design problem formulation and solution - solvent selection and substitution.

- Virginia Cunningham (USA): The first step towards sustainable business practices - the SB (SmithKline Beecham) “design for the environment” tool kit.
- Gert Holm Kristensen and Martin Andersen (Denmark): Biological control of microbial growth in the process water of molded paper pulp production - avoiding the use of biocides.
- Henrik Wenzel (Denmark) and Nilgun Kiran (Turkey): Environmental life cycle assessment of alternative scenarios for biological control of microbial growth in the process water of molded pulp production.

This meeting initiated the special one-day topic symposium for the annual meetings. The special topic was product-oriented environmental measures. The following presentations were given during the seminar:

- Steen Gade (Denmark): A challenge for modern society - uncoupling growth and pollution.
- Preben Kristensen (Denmark): The Danish product oriented environmental initiative - scope and challenges.
- Tom van der Horst (The Netherlands): The concept of eco-design and results from the Dutch eco-design programmes.
- Annik Magerholm Fet (Norway): IndEcol - NTNU’s industrial ecology programme.
- Michael Hauschild and Henrik Wenzel (Denmark): The European person equivalent - measuring the personal environmental space.
- Jasper Olesen (Denmark): Design for environment at Danish A/V producer Bang & Olufsen - cool power, new amplifier technology with 80-90% energy reduction.
- Nils Thorup (Denmark): Environmental impact assessment (LCA) energy and recycling for a circulator.
- Tomas Rydberg (Sweden): Product-oriented environmental measures at Volvo.
- Lars Lenell (Sweden): Factor 2 project on telecommunication at Ericsson Enterprise Systems AB.
- Leif Norgaard (Denmark): Practical experiences in the field of product-oriented environmental management in the textile industry.
- Anna Lise Mortensen (Denmark): The STEP model - the environmental management tool in Hartmann, including life cycle management.

The traditional field trip included visits to the Denmark Technical University and industrial symbiosis site in Kalundborg. At Kalundborg, the delegates visited the Asnaes Power Station and Novo Nordic A/S.

During the wrap-up session, the delegates selected Oviedo, Spain as the location for the 2001 annual meeting. The meeting was to be hosted by Professor Jose Coca, University of Oviedo.

**2001 Annual Meeting
May 6-11, 2001
Oviedo, Spain**



Delegate at the Computer Café' in Oviedo

The 4th annual meeting of this Pilot Study was held in Oviedo, Spain, on May 6-11, 2001. The meeting was hosted by Professor Jose Coca Prados, University of Oviedo, Department of Chemical and Environmental Engineering. This meeting included representatives from 21 countries. Countries represented at this meeting were Bulgaria, Czech Republic, Denmark, Germany, Greece, Hungary, Israel, Italy, Lithuania, Moldova, Norway, Poland, Portugal, Romania, Russia, Slovenia, Spain, Turkey, Ukraine, United Kingdom, and the United States. The meeting was sponsored by NATO CCMS, U.S. EPA, and the University of Oviedo. The meeting was held in the center of Oviedo at the Oviedo Auditorium, "Principe Felipe."

The meeting began on Sunday with a reception and get-together of the delegates. The delegates were greeted by Professor Jose Coca Prados and Dr. Subhas Sikdar, Pilot Study Director.

The technical meeting began on Monday with an introduction from Dr. Subhas Sikdar, introductions of national delegates and participants, and an overview of the meeting agenda, field visits, and events from Mr. Dan Murray, Pilot Study Co-Director. The first of several special topic presentations was given by Associate Professor Tillman Gerngross, Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire. His thought 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)
- cleaner production information via the Internet (Germany and United States)

The day concluded with a poster session and demonstration of computer-based tools and information systems to support cleaner production.

The technical meeting continued on Tuesday with an overview of programs of the U.S. National Science Foundation given by Dr. 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)
- national cleaner production updates (Czech Republic, Israel, and Lithuania)

Pilot project updates addressed using fewer natural resources and meeting peoples' needs (Moldova), new processes and materials in semiconductor manufacturing (United States and United Kingdom), and implementation of cleaner production processes in member countries (United States).

Tuesday concluded with two perspectives on university-industry cooperation from Professor Jose Coca (Spain) and Professor Jim Swindall, QUESTOR Centre, Queen's University, Belfast, Northern Ireland (United Kingdom).

The traditional field trip with technical site visits was held on Wednesday.

The topical seminar, "Environmental Challenges in the Process Industries," was held on Thursday. 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 - environmentally 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.

**2002 Annual Meeting
May 12-16, 2002
Vilnius, Lithuania**

The 5th meeting of this pilot study was held in Vilnius, Lithuania, on May 12-16, 2002. This meeting marked the end of Phase I of this pilot study. The host of the meeting was Professor Jurgis Staniskis, Kaunas University of Technology and Director of the Institute of Environmental Engineering. The meeting was sponsored by NATO CCMS, U.S. EPA, the Lithuanian Ministry of National Defense, and the Lithuanian Ministry of Environment. On Monday afternoon, the delegates enjoyed the rare opportunity of a meeting with the President of the Republic of Lithuania, Mr. Valdas Adamkas.



The President of Lithuania, Mr. Valdas Adamkas, welcomes the delegates to the Presidentila Palace.

The meeting began on Sunday with registration, introduction of the delegates, pilot project updates, and tour-de-table presentations.

The one-day topical symposium on industrial ecology was held on Monday. The symposium was opened by Mr. Arunas Kundrotas, the Lithuanian Minister of Environment. Technical presentations during the symposium included:

- Lennart Nielsen (Sweden): From pollution to industrial ecology and sustainable development.
- Annik Magerholm Fet (Norway): Industrial ecology and eco-efficiency - introduction and the concepts.
- Morten Karlsson (Sweden): Extended producer responsibility in cleaner production.
- Ari Huatala (UNEP, Paris): Strategies and mechanisms to promote cleaner production financing.
- Zaneta Stasishiene (Lithuania): Cleaner production financing - possibilities and barriers.
- Jolita Kruopiene (Lithuania): Chemical risk management in enterprises.
- Practical applications of industrial ecology in Lithuanian industry:
 - Vaclovas Sleinota (Vilniaus Vingis): Electronic industry
 - Nerijus Datekunas (Utenos Trikotazas): Textile industry
 - Arunas Pasvenskas (Klaipedos Kartonas): Paper industry

- Frantisek Bosek (Czech Republic): International implications on industrial ecology - utilization of cleaner production in a dairy plant and poultry processing plant.

Monday's final session was the computer café with included demonstrations of software that is helpful to cleaner production.

The traditional field trip with technical site visits was held on Tuesday. Visits were made to Snaige, a refrigerator production company; Alytaus Tekstile, a textile company; and Alita, a wine and sparkling wine production company.

Wednesday's session included several project updates and technical presentations,

- Steve Weiner (USA): Industries of the future - partnerships for improving energy efficiency, environmental performance and productivity.
- Gueorgui Kagramanov (Russia): Ceramic membrane applications in clean processes in Russia.
- Jim Swindall (United Kingdom): An update on government support for clean products and processes in the United Kingdom.
- Jose Coca (Spain): Waste minimization, recolorization and recycling of solid waste in Spain.
- Jurgis Staniskis (Lithuania): Lithuanian cleaner production center.
- Thomas Chapman (USA): Programs of the U.S. National Science Foundation related to clean processing.
- Dan Murray (USA): Pollution prevention tools.
- Aysel Atimtay (Turkey): Reuse of waste materials of iron-steel industries and development of sorbents from these materials for absorption of hydrogen sulfide in waste gases.
- Henrik Wenzel (Denmark): The Danish center for industrial water management.
- Teresa Mata (Portugal): Life cycle assessment of gasoline blending options.

In the wrap-up discussions, the delegates discussed how to move forward in Phase II and to work together in the implementation areas described in the Phase II proposal. These implementation areas will address tools for assessment of pollution prevention and sustainability and for the design of cleaner products and processes; cleaner production techniques in priority industrial areas; and electronic dissemination of information and knowledge of cleaner products and processes. The delegates voted to conduct the next meeting in Italy in May 2003.

**2003 Annual Meeting
May 11-15, 2003
Cetraro, Italy**



Group photo from the Cetraro, Italy meeting in 2003

The 6th annual meeting of this pilot study was held in Cetraro, Italy on May 11-15, 2003. The meeting was attended by representatives of 24 countries. The meeting was hosted by Professor Enrico Drioli, University of Calabria. The meeting was sponsored by NATO CCMS, U.S. EPA, the Italian National Research Council (CNR), and the University of Calabria. The countries represented at this meeting were Bulgaria, Czech Republic, Denmark, Germany, Greece, Hungary, Israel, Italy, Lithuania, Norway, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Spain, South Africa, Sweden, Turkey, Ukraine, United Kingdom, and the United States.

This meeting was the first meeting of Phase II of the pilot study. The goals of Phase II were:

- To support the development of eco-efficiency and sustainability indicators and promote consistency and harmonization of their application
- To examine and exchange information on state-of-the-art advancements in product design and process development in service and industrial sectors of importance to participating nations
- To develop a web-based portal for the dissemination of pilot study results and improved awareness of related global developments
- To stimulate and facilitate productive collaboration among all participating nations

The meeting began on Sunday afternoon with Subhas Sikdar presenting his insights into the future of Phase II and a technical workshop on sustainability metrics. The workshop was followed by many technical presentations including,

- Horst Pohle (Germany): Selection and use of environmental indicators in different NATO member states.
- David Pennington (United Kingdom): Life cycle impact factors.

- Annik Magerholm Fet (Norway): Sustainability reporting in European regions.
- Gyula Zilahy (Hungary): The role of environmental management accounting in corporate environmental management.
- Dan Murray (USA): TRACI - tool for the reduction and assessment of chemical and other environmental impacts.

On Monday morning, delegate presentations continued as follows:

- Teresa Mata (Portugal): Design and simulation of environmentally conscious chemical processes.
- Jurgis Staniskis (Lithuania): Sustainable industrial development in Lithuania.
- Chris Buckley (South Africa): Clean products and processes activities at the University of Natal, South Africa.
- Henrik Wenzel (Denmark): Breakthrough of water reuse in textile industry through development of generic water recycle schemes.
- Jim Swindall (United Kingdom): Update on the topic of ionic liquids.

On Monday afternoon, the delegates toured the University of Calabria and the CNR Membrane Center. The delegates were greeted by the Rector of the University of Calabria and later by the Mayor of Cosenza.

The traditional field trip with industrial site visits was held on Tuesday. The technical visits were to Amarelli Liqorice, OSA Agro-Foods, and Mediterranea R&S.

On Wednesday, the one-day topical symposium on process intensification was held. Technical presentations included:

- George Gallios (Greece): Process intensification at the European Union level - current projects and future plans.
- Andrzej Doniec (Poland): Wettability determination as an important factor in designing environmental performance of some industrial processes.
- Ralph Pike (USA): Development and integration of new processes for greenhouse gases management in multi-plant chemical production complexes.
- Gueorgui Kagramanov (Russia): Studies on the purification of non-water media by ceramic membranes.
- Jose Coca (Spain): Several alternatives for the separation of organic acids as examples of process intensification.
- Antonio Martins (Portugal): Process intensification by modeling and modifying packed bed reactor.
- Alessandra Criscuoli (Italy): New technologies for improving gas liquid transfer processes and catalytic reactions.
- Miroslava Vaclavikova (Slovak Republic): Slovakian industry byproducts in intensification of wastewater treatment processes.
- Aysel Atimtay (Turkey): Reuse of waste materials from the zinc industry for sorption of hydrogen sulfide in gas clean-up.
- Chris Buckley (South Africa): Setting up waste minimization clubs.

On Thursday, two additional technical presentations were given:

- Peter Glavic (Slovenia): Sustainable development using macroeconomic and microeconomic indicators.

- Jose Coca (Spain): Chemical dispersants for the remediation of oil spills.

In the wrap-up discussion, several areas for future focus of the pilot study were identified

- Sustainability metrics and reporting mechanisms
- Train the trainer, implement environmental management accounting.
- Education and training in sustainable development
- Cleaner production policy in transition economy countries
- Indicators for potential new sustainable technologies
- Waste minimization clubs

The meeting concluded with the selection of Budapest, Hungary, as the location for the 2004 annual meeting.

**2004 Annual Meeting
May 1-6, 2004
Budapest, Hungary**



Visit to a cleaner production site and technical discussion at a break.

The 7th meeting of this pilot study was held at the Budapest University of Economic Sciences and Public Administration on May 1-6, 2004. The host for the meeting was Dr. Gyula Zilahy. Of the 31 countries involved in the pilot, 27 were represented at this meeting. The meeting was sponsored by NATO CCMS, U.S. EPA, and the Budapest University of Economic Sciences and Public Administration. Delegates from the following countries were present at this meeting: Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Egypt, Georgia, Germany, Greece, Hungary, Israel, Italy, Lithuania, Moldova, Norway, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Spain, Turkey, Ukraine, United Kingdom and the United States. This meeting was the largest of the pilot study to date.

The opening session was held on Sunday with Dr. Sandor Kerekes, Dean, Budapest University of Economic Sciences and Public Administration, welcoming the delegates to Budapest. Subhas Sikdar, Pilot Study Director, held an open forum on the status of proposed projects for multi-country collaboration including,

- Sustainability metrics and reporting mechanisms
- Training the trainers to implement environmental management accounting (EMA)
- Education and training in sustainable development
- Cleaner production policy in transition economy countries
- Indicators for potential new sustainable technologies
- Waste minimization clubs

On Monday, several special invited speakers and delegates made technical presentations including,

- Professor D. Bhattacharya (USA): Functionalized membranes for separations.
- Dr. John Cihonski (USA): Spinning reactor applications in process intensification.
- Professor Farhang Shadman (USA): Update on environmentally benign semiconductor manufacturing.
- Teresa Mata (Portugal): Designing environmentally sustainable chemical processes.
- Professor Gueorgui Kagramanov (Russia): New flotation processes and equipment for wastewater purification.
- Ales Komar and Frantisek Bozek (Czech Republic): Measures of cleaner production in food industry and their environmental benefits.
- Professor Aysel Atimtay (Turkey): Comparison of the application of BREFs in EU member and candidate countries.

The delegates visited the Hungarian Environmental Minister at the Hungarian Parliament on Monday afternoon. The Minister updated the delegates on the environmental protection work going on in Hungary.

On Tuesday, the delegates visited three industrial sites where cleaner production is practiced, as part of the traditional field trip. The visits were to Herend Porcelain Manufacturing; Guntner Tata Ltd., a manufacturer of industrial heat exchangers; and the Szollosi Wine Company.

On Wednesday, the delegates were greeted by the Rector of Budapest University prior to the one-day topical symposium. The theme of this symposium was environmental education. The symposium was divided into four sessions, each with several presentations including,

Session I:

- Peter Glavic (Slovenia): Education in environmental engineering in Europe.
- Sandor Kerekes (Hungary): Future of environmental education in Hungary.
- Antonio Martins (Portugal): Educating for sustainability - challenges and trends.

Session II:

- Laszlo Valko (Hungary): Environmental Education in Hungary.
- Gilbert Rochon (USA): Education in sustainable production in U.S. universities.
- Ronald Kontar (Hungary): Environmental education in Slovakia.
- Zsuzsanna Szerenyi (Hungary): Environmental education at the Budapest University of Economic Sciences and Public Administration.
- Chaim Forgacs and David Wolf (Israel): Education in Israel on sustainability.

Session III:

- Akos Redey (Hungary): Implementation of management systems in higher education.
- Jurgis Staniskis (Lithuania): Experience of international M.Sc. program in environmental management and cleaner production.
- Gabor Onodi (Hungary): Environmental issues in agricultural higher education.
- William Zadorsky (Ukraine): About training of technicians at high schools in Ukraine for realization of sustainable development concepts.

Session IV:

- Henrik Wenzel (Denmark): Sustainable industrial production - undergraduate course on methods and tools in industry's environmental work.
- Jim Swindall (United Kingdom): Marie Curie Host Fellowship for early stage research training.

On Thursday, additional delegate presentations were given including,

- Annik Magerholm Fet (Norway): Sustainability metrics and reporting mechanisms in the European region.
- Henrik Wenzel (Denmark): Environmental assessment of enzymatic biotechnology - case on the application of phytase to pig feed.
- Jose Coca (Spain): Characterization of adsorbents for VOC removal by inverse gas chromatography.
- Susete Dias (Portugal): Update on the use and capabilities of constructed wetlands.

At the wrap-up session, the delegates selected Porto, Portugal to host the 2005 annual meeting. Due to planning difficulties, the location for the 2005 meeting was changed to Aalesund, Norway.

**2005 Annual Meeting
June 19-24, 2005
Aalesund, Norway**

The 8th annual meeting of this pilot study was held in Aalesund, Norway on June 19-24, 2005. Of the 31 countries involved in this Pilot Study, 27 sent representatives to this meeting. The meeting was organized and hosted by Professor Annik Magerholm Fet, Norwegian University of Science and Technology (NTNU). The primary sponsors of the meeting were NATO CCMS and U.S. EPA, with many local sponsors. Countries represented at the meeting were Azerbaijan, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Georgia, Germany, Greece, Hungary, Israel, Italy, Lithuania, Moldova, Norway, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Sweden, Turkey, Ukraine, United Kingdom and the United States. The United States of America, Israel, Czech Republic, Belgium, and Norway had multiple representatives at this meeting. New delegates from Azerbaijan and Sweden attended this meeting.



Group photo from the Alesund, Norway meeting in 2005 and visit to a fish processing plant.

On Sunday evening, the meeting began with a reception and get-together. On Monday morning, the delegates were greeted at Aalesund City Hall by Mayor Arve Tonning. A very special welcome and address was given by Ms. Kristin Krohn Devold, Norwegian Minister of Defense. She highlighted the importance of cleaner production, sustainability, and Norway's role in supporting international peace and security. Delegate presentations began on Monday afternoon and included the following:

- Aysel Atimtay (Turkey): A comparison of the application of BREFs in EU candidate countries and in Turkey.
- Andrzej Doniec (Poland): A cellular concrete material used for thorough cleaning of wastewater generated in electroplating process.
- Tom Chapman (USA): Mercury emissions, both from chlorine plants and power plants.
- Viorel Harceag (Romania): Towards a sustainable development of water resources in Romania.
- Alexandru Stratulat (Moldova): Cleaner production in the Republic of Moldova.
- Hakan Rodhe (Sweden): Assessing technology uptake - a model developed for cleaner production programs.
- William Zadorsky (Ukraine): Tools and methods for innovative cleaner technologies.
- Stefka Tepavicharova (Bulgaria): European scientists for clean Black Sea.
- Frantisek Bozek and Ales Komar (Czech Republic): Military unit cleaner production project.
- Horst Pohle (Germany): Sustainable production - some aspects.
- Subhas Sikdar (USA): Mini-workshop on sustainable technologies

On Tuesday, the traditional field trip was held with visits to three industrial facilities. The first visit was to Ulstein ASA, a ship builder for the offshore oil and fishing industries. The second visit was to Hjellegerde AS, a high-end furniture manufacturer. The third visit was to Sandella AS, a polyurethane foam products manufacturer.

The topical symposium was held on Wednesday and part of Thursday and it addressed the environmental challenges in marine biotechnology, product design and innovation, and cleaner production tools and methods. The symposium was cosponsored and hosted by Aalesund University College. The delegates and symposium attendees were greeted by Rector Karl Johan Skaarbrevik. The technical presentations included:

Session I: Biotechnology

- Marianne Synnes (Norway): Learning from the deep-sea organisms.
- Knut Sjaastad (Norway): Composition of marine biofilms on different submerged surfaces.
- Niels Peter Ravsbeck (Denmark): Biofilm research at the University of Aarhus.
- Henrik Wenzel (Denmark): Environmental sustainability of enzymatic biotechnology.
- Kamal Ewida (Egypt): A sustainable approach to the recycling of rice straw through pelletization and controlled burning.
- Peter Glavic (Slovenia): Committing universities to sustainable development.

Session II: Product Design and Innovation

- Per Erik Dalen (Norway): Industrial innovation in the More region.
- Hans Petter Hildre (Norway): Regional and global perspective on product design and innovation.
- Per Walde (Norway): Energy savings in fish processing.
- Carlo Vandecasteele (Belgium): Flemish chemical industry on the way to sustainability.

Session III: Cleaner Production Tools and Methods

- Farhang Shadman (USA): Environmental aspects of nanotechnology and nano-manufacturing.
- Ksenija Vitale (Croatia): Nanotechnologies in environmental and public health.
- Alessandra Criscuoli (Italy): Potentialities of membrane operations in the logic of the process intensification.
- Alexander Omelchenko (Canada): Modern tools and methods of water treatment for improving living standards - presentation of the book.
- Antonio Martins and Teresa Mata (Portugal): A framework for sustainability metrics.
- Chantal Block (Belgium): Indicators for the evaluation of the environmental impact of industry.
- Jurgis Staniskis (Lithuania) and Annik Magerholm Fet (Norway): Industrial ecology and sustainability reporting in the Klaipeda Region of Lithuania - A lesson learned.
- David Wolf (Israel): Slow release chemicals and the effect on the environment.
- Harad Yndestad (Norway): Understanding environmental influence on marine systems.

On Thursday afternoon, the delegates conducted another technical site visit to Fjordlaks, a cod fish processing plant.

On Friday, the technical meeting was held at Atlanterhavsparken, the largest aquarium in Northern Europe. Delegate technical presentations included the following:

- Jim Swindall (United Kingdom): Managing the interface between cooperative and contract research.
- Gilbert Rochon and Buck Sharpton (USA): Remote sensing project proposal.
- Khatuna Gogaladze (Georgia): Cleaner production related processes in Georgia.
- Miroslava Vaclavikova (Slovak Republic): Preparation and sorption properties of Fe-nanomaterials for removal of toxic metal ions from waters.

- George Gallios (Greece): Color removal from water streams using power ultrasounds and flotation.
- Gueorgui Kagramanov (Russia): Purification of wastewaters by membrane flotation.

By majority vote, the delegates selected Istanbul, Turkey and Professor Aysel Atimtay to host the 2006 meeting.

**2006 Annual Meeting
May 7-12, 2006
Istanbul, Turkey**



Delegates listening to a talk by a colleague from the Istanbul, Turkey meeting in 2006.

The 9th annual meeting of this pilot study was held in Istanbul, Turkey, on May 7-12, 2006. The meeting was sponsored by NATO CCMS, the U.S. Environmental Protection Agency and the Middle Eastern Technical University (METU). The host of the meeting was Professor Aysel Atimtay of METU. Of the 31 countries involved in this pilot, 22 sent representatives to this meeting. The United States of America, Czech Republic, Portugal, Belgium and Turkey each had multiple representatives at this meeting. Other countries represented at the meeting were United Kingdom, Slovenia, Spain, Greece, Italy, Lithuania, Israel, Ukraine, Egypt, Russia, Slovak Republic, Bulgaria, Romania, Moldova, Hungary, Canada, and Croatia. In addition, Mr. E. Sanguineti, NATO Headquarters, Public Diplomacy Division, Threats and Challenges Section, Brussels, Belgium, attended the meeting.

The meeting started on Sunday evening with a reception and get-together. The opening session was on Monday morning with welcoming comments presented by Professor Fatos Y. Vural, Vice Rector of METU; the Mayor of Istanbul; and Mr. Gazi Kaya, the Deputy Governor of Istanbul. The following presentations followed the opening session:

- E. Sanguineti (NATO CCMS): CCMS and the security through science programs.
- Jim Swindall (United Kingdom): Sustainability and green chemistry.

- Antonio Martins and Teresa Mata (Portugal): Integration of a sustainability indicators framework in corporate strategy.
- Peter Glavic (Slovenia): Approaches for minimization of industrial water usage.
- Chantal Block (Belgium): Sustainable processes in the steel industry in Flanders.
- Jose Coca (Spain): Evaluation of several zeolites as adsorbents for sulfur compounds by inverse gas chromatography.
- Subhas Sikdar (USA): Mini-workshop on metrics for sustainable technologies.

The traditional field trip was held on Tuesday with visits to three technical sites of interest to the pilot study. The first visit was to Turkey's premier research center, Marmara Research Center in Tubitak. The group was greeted by Dr. Mehmet Demirel, Vice President of Strategic Planning and Business Development. Also, two presentations were also provided by I. Baylakoglu, Senior Researcher (EU directives for electronics industry) and A. Baban, Vice Director (Sustainable concepts towards zero outflow municipalities). The second visit was to the Kocaeli Chamber of Industry. The third visit was to Ford Autosan automobile assembly facility.

On Wednesday, the one-day topical symposium, addressing water recycling and reuse, was held. The following technical presentations were provided:

- Dan Murray (USA): U.S. EPA's guidelines for water reuse.
- Enrico Drioli (Italy): Membrane engineering in water reuse and recycle.
- M. Kitis (Turkey): Treatment of campus wastewater by membrane bioreactor for potential reuse in irrigation.
- George Gallios (Greece): Textile wastewaters - water reuse and dyestuff removal and degradation.
- A. Baban (Turkey): Water segregation and reuse in textile industry.
- Farhang Shadman (USA): Water use, reuse, and recycling in micro- and nano-manufacturing.
- A. B. Tanik (Turkey): Studies on some selected urban wastewater treatment plant effluents of Turkey to search their reuse potential in agriculture.
- Jurgis Staniskis (Lithuania): Water saving, reuse and recycling in industry - cleaner production opportunities.
- G. Akcin (Turkey): Efficient management of wastewater, its treatment and reuse in the Mediterranean countries - EMWATER.
- Chaim Forgacs (Israel): Problem and applications of water reuse in Israel.
- William Zadorsky (Ukraine): Improving water quality through low-cost upgrading of a water treatment facility accompanied by abandonment of chlorination.

On Thursday, national delegates delivered various technical and programmatic presentations:

- Carlo Vandecasteele (Belgium): Treatment of the residual fraction of domestic waste - the Flemish case.
- Kamal Ewida (Egypt): Treatment of wastewaters through adsorption of heavy metals by natural clays.
- George Gallios (Greece): Industrial wastewater treatment - metals recovery and water reuse.
- Gueorgui Kagramanov (Russia): Wastewater treatment with integrated membrane-electroflotation method.

- Enrico Drioli (Italy): Application of new indexes for comparing membrane operations to traditional techniques.
- Miroslava Vaclavikova (Slovak Republic): Arsenic removal from waters using magnetically modified zeolite.
- Aysel Atimtay (Turkey): Color removal from textile wastewaters by changing surface properties of adsorbent materials (Clinoptilolite).
- Stefka Tepavicharova (Bulgaria): Thermodynamic modeling of inorganic chemical species in natural polluted waters.
- Ales Komar (Czech Republic): The national cleaner production program - benefits assessment.
- Franticek Bozek (Czech Republic): Utilization of cleaner production and the best available technology in a food processing plant.
- Chaim Forgacs (Israel): Enforcement of environmental regulations in Israel - 2005.
- Viorel Harceag (Romania): Urban water services development - Romanian perspective.
- Alexandru Stratulat (Moldova): Cleaner production activities in Moldova.
- G. Harangozo (Hungary): Factors behind cleaner production in the Hungarian manufacturing industry - results of a survey.
- Jose Coca (Spain): Carbon dioxide emissions in Spain - main sources and capture possibilities.

Technical presentation from national delegates continued on Friday:

- Gilbert Rochon (USA): Networking satellite ground stations to support global science toward a distributed shared spatial data archive and grid access to near real-time remote sensing data.
- Alexander Omelchenko (Canada): Efficient technology for precious metals extraction from secondary raw materials.
- Miroslava Vaclavikova (Slovak Republic): Red mud - a potential sorbent for removal of heavy metal cations.

Subhas Sikdar led the wrap-up discussions. The delegates selected Porto, Portugal as the location for the 2007 meeting after the presentation by Antonio Martins and Teresa Mata of the University of Porto.

**2007 Annual Meeting
May 5-9, 2007
Porto, Portugal**



Reception of the Pilot delegates at the Mayor's office in Porto, Portugal in 2007 and an evening dinner.

The 10th annual meeting of this pilot study was held in Porto, Portugal. Of the 31 countries involved in this pilot, 24 sent representatives to this meeting. In addition, Dr. Deniz Beten, Director, NATO SPS Program, was in attendance. The meeting was sponsored by NATO SPS, the U.S. Environmental Protection Agency and the University of Porto. Multiple representatives from the United States of America, Czech Republic, Belgium, Portugal, Italy, Israel, the United Kingdom and Turkey were in attendance at this meeting. In addition, representatives from Slovenia, Spain, Greece, Lithuania, Azerbaijan, Russia, Slovak Republic, Bulgaria, Czech Republic, Romania, Moldova, Hungary, Canada, Poland, Norway, Denmark and Croatia were in attendance.

The meeting started with a reception, delegate introductions and get-together on Sunday evening. The opening session was held on Monday morning with welcoming addresses by Professor Marques dos Santos, Rector of the University of Porto; Dr. Subhas Sikdar, Pilot Study Director; Dr. Deniz Beten, Director, NATO SPS Program; and Mr. Daniel Murray, Pilot Study Co-Director. The following technical presentations followed:

- Aysel Atimtay (Turkey): Overview of the 2006 annual meeting held in Istanbul.
- Jurgis Staniskis (Lithuania): Product life cycle design - Lithuanian case study.
- Jose Coca-Prados (Spain): Formulation, characterization and treatment of metal working oil-in-water emulsions.
- Alexander Omelchenko (Canada): Water-born environmental cardiovascular risk factors.
- Chaim Forgacs (Israel): Wastewater treatment in industrial parks - the Ramat Chovav experience.
- Andrezj Doniec (Poland): The problems of establishing symbiotic connections in industrial parks.
- David Wolf (Israel): Incorporation and transfer of sustainable technologies in Israel.
- Ksenija Vitale (Croatia): Sustainable environment through sustainable working conditions.

- Annik Magerholm Fet (Norway): Global production and corporate social responsibility.
- Viorel Harceag (Romania): Biofuels could be a solution on route to sustainable transport.
- George Gallios (Greece) and Miroslava Vaclavikova (Slovak Republic): Removal of arsenic from water sources by a new synthetic resin.
- Chantal Block (Belgium): Environmental performance indicators for industrial sites.
- Peter Glavic (Slovenia): Sustainable development in higher education.
- Alexandra Polzin (Portugal), Antonio Martins (Portugal), Teresa Mata (Portugal), and Subhas Sikdar (USA): Application of a sustainable metrics framework in a metallurgical company.
- Subhas Sikdar (USA): A mini-workshop on indicators for sustainable development - definition and frameworks.

The one-day topical symposium, Best Practices for Incorporation and Transfer of Sustainable Technologies in Industry, was held on Tuesday. The symposium was kicked-off by Subhas Sikdar, Pilot Study Director, and Professor Alvaro Cunha, Faculty of Engineering, University of Porto. A keynote presentation was given by Dr. Deniz Beten. She provided an elaborate description of various different way NATO and partner country representatives can interact with one another using NATO SPS grant mechanisms. Additional technical presentations were provided as follows:

- Jim Swindall (United Kingdom): Methods and best practices for technology transfer between university and companies.
- Farhang Shadman (USA): Sustainability challenges and opportunities in nano-scale manufacturing.
- Adisa Azapagic (United Kingdom): Transfer of sustainable technologies - examples from the UK
- Gilbert Rochon (USA): Establishing a shared spatial database of archival and real-time remotely sensed data for NATO countries and affiliates.
- Henrik Wenzel (Denmark): Environmental assessment of second generation bioethanol.
- Pedro Pacheco (Portugal), Ruie Pedroto (Portugal), and Rui Campos (Portugal): Organic pre-stressing - a new sustainable construction technology.
- Pedro Vieira (Portugal): Manufacturing a cylinder using a sustainable technology.
- Knut Kappenberg (Portugal): Wood-based panels show their colors - forward-looking materials for sustainable impressions.
- Francisco Araujo (Portugal): Industrialization of advanced optical technologies for environmental monitoring.
- Joao Sousa (Portugal) and Gil Goncalves (Portugal): Unmanned vehicles for environmental data collection.
- Joaquim Mendes (Portugal): New sensor for fouling measurement.
- Jorge Goncalves (Portugal): Closing from the Vice-Rector of the University of Porto

The traditional field trip was held on Wednesday. Three technical site visits were scheduled for the delegates. The first was a visit to a manufacturing facility of the cork products company, Amorim & Irmaos S.A. After a presentation on the growth and harvesting of cork, a manufacturing facility for natural cork stoppers for reserve wines and a facility for the manufacture of products from granulated and agglomerated cork was provided. The second visit was to a felt hat manufacturing company. This company, FEPSA-Feltros de Portugal S.A., makes hats from wool, rabbit and beaver fur. The third visit was to two production units of Simoldes Group. One facility manufactures molds for automotive parts and the other facility produces plastic components for the automotive industry.

Delegate technical presentations continued on Thursday with the following:

- Gueorgui Kagramanov (Russia): Use of membrane filtration methods for treatment of heavy metals containing wastewaters in combination with flotation.
- Alessandra Criscuoli (Italy): Application of membrane contactors for treating polluted water.
- Dan Murray (USA): Sustainable water infrastructure in the U.S. - battling the aging process.
- Carlo Vandecasteele (Belgium): Waste incinerators - source or sink of toxic POPs.
- Thomas Chapman (USA): Applications for electrochemistry for clean processing.
- Stefka Tepavicharova (Bulgaria): Best practices for incorporation of sustainability in Bulgarian sea-salt industry.
- Gyula Zilahy (Hungary): Support of sustainable production and consumption initiatives in Hungary.
- Stefka Tepavicharova (Bulgaria): Thermodynamic modeling of inorganic chemical species in natural polluted waters.
- Ales Komar and Franticek Bozek (Czech Republic): Implementation of BAT of sanitation of relict burdens.
- Franticek Bozek (Czech Republic): Utilization of cleaner production and the best available technology in a food processing plant.

The wrap up of the meeting included the selection of Greece as the host of the 2008 meeting. Unfortunately, for unavoidable reasons, Greece had to rescind its offer to host the meeting. Subsequently, Dr. Horst Pohle (Germany) offered to host the 2008 meeting. It was agreed that the 2008 meeting, the final meeting of this Pilot Study, would be held in Berlin in May 2008.

On a sad note, the delegates were informed of the passing of the Egyptian delegate to the Pilot Study, Dr. Kamal Ewida. We fondly remember him for his contributions to the meetings and his enthusiasm for our mission.

**2008 Annual Meeting
May 4-9, 2008
Berlin, Germany**



Group photo from the Berlin, Germany meeting in 2008

The 11th annual meeting of the Pilot Study was held in Berlin, Germany. Of the 31 countries involved in this pilot study, 23 sent representatives to this final meeting. In addition, it was an honor to have the topical symposium start with an introduction by Mr. Thomas Holzmann, Vice President, Federal Environment Agency, Germany. Mr. Holzmann thanked the delegates for their efforts in the field of sustainable and renewable energy and their roles in promoting science for peace, security, stability and solidarity. He acknowledged that while the topic of biomass production is controversial, Germany and the EU have ambitious targets to achieve. He concluded by wishing everyone a wonderful stay in Berlin.

The meeting was efficiently organized and included two days of technical presentations, one day for field trips to four biomass facilities, Thursday's symposium, and wrapping up on Friday with final presentations and discussions. This year, the meeting was mainly sponsored by NATO SPS, the U.S. EPA and the Federal Environment Agency of Germany (Umwelt Bundes Amt - UBA). Typically, one delegate per country attends the meeting. However, the United States of America, Czech Republic, Belgium, Portugal, Italy and Germany each had more than one attendee at this meeting. The countries represented in this meeting also included Azerbaijan Republic, Canada, Croatia, Denmark, Greece, Hungary, Lithuania, Norway, Poland, Republic of Moldova, Romania, Russia, Slovak Republic, Slovenia, Spain, Ukraine and Turkey.

The meeting started on Sunday evening with a reception, delegate introduction and get-together. The opening session on Monday was addressed by the meeting host, Dr. Horst Pohle, UBA; Dr. Subhas Sikdar, Pilot Study Director and Mr. Dan Murray, Pilot Study Co-Director. Technical presentations on Monday included:

- Jurgis Staniskis (Lithuania): Sustainable consumption and production - How to make it possible.
- Carlo Vandecasteele (Belgium): Evaluation of the eco-efficiency of the Flemish Industry (1995-2006)
- Alexander Omelchenko (Canada): Surviving Lead - The grave has been dug, the coffin prepared, the service arranged, but the body just would not lie down in the coffin.
- Alexandru Stratulat (Moldova): Energy efficiency in Moldova.
- Annik Magerholm Fet (Norway): From cleaner production to corporate social responsibility - an overview of tools and methods.
- Andrezj Marcinkowski (Poland): Technical and organizational problems accompanying a design of symbiotic connections between enterprises.
- Viorel Harceag (Romania): Industrial ecology from theory to practice.
- Chantal Block (Belgium): Eco-industrial parks, a collaboration between Flanders, Poland and Romania, outgrowth of the NATO SPS pilot study on clean products and processes.
- William Zadorsky (Ukraine): Cleaner production theory, tools, methods and experience of realization.

The second day of technical presentations on Tuesday included the following:

- Miroslava Vaclavikova (Slovakia): Arsenic removal from water streams using Fe-modified zeolite - A column study.
- Gueorgui Kagramanov (Russia): Use of membrane filtration methods for treatment of heavy metals containing wastewaters in combination with flotation.
- Farhang Shadman (USA): Manufacturing in nano-scale: environmental opportunities and pitfalls.
- George Gallios (Greece): Removal of color from water streams by advanced oxidation methods.
- Alessandra Criscuoli (Italy): New application of membrane contactors.
- Dan Murray (USA): Update on sustainable water infrastructure and water reuse in the U.S.
- Gyula Zilahy (Hungary): Sustainable consumption - the human dimension.
- Gerd Winkelmann (Germany): Hazard prevention and emergency planning at transboundary rivers in the UN ECE region.
- Vagif Baghiyev (Azerbaijan): Catalytic conversion of ethanol to chemicals as examples of catalysis in a sustainable fine chemical industry.
- Ales Komar and Frantisek Bozek (Czech Republic): Problems of biomass exploitation in the Czech action area.
- Jose Coca (Spain): Technical and economic evaluation of biodiesel production by enzymatic catalysis.
- Aysel Atimtay (Turkey): The role and the importance of biomass in sustainable development.
- Teresa Mata and Antonio Martins (Portugal): Prospects for biodiesel production and future evolution.

On Wednesday, a field trip was held to visit four biomass facilities which was a perfect lead into Thursday's symposium topic of biomass: resources, conversion, markets and policies. The first stop was the Selbeland biogas plant. Selbeland has a plant capacity of 340 kWh. The process used to generate the biogas is wet fermentation using regenerative agricultural resources (substrate was a mixture of cow manure and various silages). Electricity produced from this plant

is fed into the national grid. The next stop was the Fehrebellin biogas plant (Rhinmilch GmbH Agrargesellschaft). This plant boasted a larger capacity yield of biogas generation again using a combination substrate of cow manure and silage. The tour directed the group through several process stages and showcased state-of-the-art technology upgrades. The third stop was the Ketzin biogas plant. This plant, built in 2007-08, was unlike the others, as it is classified as a dry fermentation facility and is sponsored by Edisnatur Erneuerbare Energien GmbH. Using a mixture of maize silage and grain, this plant claims to produce a more purified gas which is fed directly into the national pipe system. Schwanebeck biogas plant was the last facility toured. Located adjacent to a pig breeding farm, this plant collects the liquid pig manure and accepts third party-substrates of fat and food wastes to generate biogas used to process heat, operate equipment, generate hot water, and provide heating for the pig-breeding facility.

The one-day topical symposium on biomass: resources, conversion, markets and policies, was held on Thursday. The opening presentation was made by Ms. Ozlem Ozgul Yilmaz, Consultant to NATO Public Diplomacy Division and Science for Peace and Security. She discussed the new structure, roles and objectives of the NATO environmental security panel. Symposium presentations included:

- Subhas Sikdar (USA): Biomass to biofuels: environmental, societal and economic issues.
- Michael Herr (Germany): Political and legal framework in Germany.
- Frank Scholwin (Germany): Availability and utilization of biomass resources - overview and technological options at the example of biogas production and Production of biogas at different German biogas plants in agriculture and waste management.
- Franziska Muller-Langer (Germany): Overview of biofuel technologies.
- Uwe Fritsche (Germany): Sustainability standards for biofuels in Germany - status and perspectives.
- Henrik Wenzel (Denmark): Life cycle assessment study comparing biogas for transportation with other biofuels.
- Gilbert Rochon (USA): Biofuels - the dialectics of energy security and food security.
- Peter Glavic (Slovenia): Biomass and biofuels - the solution or another illusion?

The final session of the meeting was held on Friday morning. The following presentations were given:

- Gilbert Rochon (USA): The Kamal Ewida Earth Observatory NATO SPS Grant.
- Enrico Drioli (Italy): An integrated membrane system for advances biogas production, recovery and valorization.
- Annik Magerholm Fet (Norway): Biofuel and eco-efficiency - exemplified by small recreation boats.
- Jurgis Staniskis (Lithuania): The development of projects and activities on environmental security.

Subhas Sikdar and Dan Murray led the closing discussions of the meeting. Discussions revealed interest in focusing future activities on water infrastructure in Mediterranean Dialect countries, advanced research workshops in hazard prevention and environmental security, and continued focus on biofuels. Delegates were asked to reflect on the benefits of their participation of this pilot study. Overall, there was an overwhelming exchange of pleasure and appreciation shown by each delegate. It was agreed that the benefits from new partnerships, joint ventures and communications exchanged over the past eleven years are immeasurable.

CHAPTER 3

Spin-offs from the Pilot Study

Israel: David Wolf and Chaim Forgacs, Ben Gurion University

The decade of the NATO/CCMS Pilot Study on Clean Products and Processes coincided with the increasing awareness and interest on environmental problems in Israel including the establishment of the Environmental Protection Ministry.

This Pilot Study should serve as a model of how a world problem should be handled and how the solution should be dissipated among Nations. The Pilot Study dealt with a wide range of topics in the field of environment and eco-systems. Each country presented their problems and solutions and the technology transfer means of dissipation. We, the Israeli team, have also attempted to share our problems and experiences with the members of the Pilot Study and at the same time to bring back home new ideas and solutions to problems from other countries' experiences, and to present them to our Industrial people, Governmental agencies and Academic institutions.

Our contribution to Israel was the establishment of a department of Environmental Engineering at the Ben-Gurion University and to include environmental courses in the curriculum of the department of Chemical Engineering at the Ariel University Center.

Also research work in this field is done by graduate students in both Institutions. The most important subjects studied, researched and implemented are water desalination, water treatment and reuse, pollution of rivers and water tables, solid waste treatment and recycle and introduction of clean and sustainable technologies in industrial parks.

The organizers of these meetings, in the various countries, have always succeeded to prepare a rich program that included annual reports by the participating countries, case studies, academic lectures, special study subjects, professional plant tours and many fruitful discussion sessions.

This Pilot Study produced many interactions and cooperation between the participating countries. We in Israel have also hosted visitors from the USA and UK and we are now trying to join Romania in the endeavor to establish a multi-nation research group. The personal friendship with the participants of the many countries will always be a great help in the continuation of our professional and personal relationship.

To Subhas and Dan, who devoted so much time, effort and talent for the success of this project, we want to thank very much. We also want to thank them for the great opportunity we had to be part of such a distinguished group of people. This project they can definitely consider as a highlight chapter of their professional activities.

USA: Subhas K. Sikdar and Dan Murray, U.S. Environmental Protection Agency

The Pilot Study made possible creative and cost-effective technical collaborations between the National Risk Management Research Laboratory (NRMRL) of the U.S. Environmental Protection Agency and several universities of the Pilot member counties. The most significant of these collaborations are briefly described below:

1. University of Oviedo, Spain and Russian Academy of Sciences: Prof. Jose Coca of Spain, Prof. Georgie Kagramanov of the Russian Federation, and Subhas Sikdar, the Study Director proposed and received funding of a linkage grant from NATO SPS to explore the possibility of developing a low-cost process for removing sulfur from gasoline and diesel to satisfy the regulatory requirements of ultra-low sulfur transportation fuels in Europe and the United States. This collaboration looked at several avenues of achieving the end. The US EPA succeeded in demonstrating the proof of concept in the laboratory of a sorption process for achieving the technical goal of reaching less than 5 ppm of sulfur in model fuel. The United States Department of State subsequently funded a \$400,000 project, proposed by the U.S. EPA, at the Russian and Ukrainian Academies of Sciences to do further research with the aim of developing a scalable process for commercialization. U.S. EPA is actively working with the Ukrainian and Russian researchers on this development. A U.S. patent on the process is pending. This project is ongoing.
2. University of Calabria, Italy: Prof. Enrico Drioli of the University of Calabria and Subhas Sikdar of NRMRL started a collaborative project to develop specialty membranes for removing organics from aqueous medium. Dr. Alberto Figoli traveled to Cincinnati twice to work with NRMRL to collect data on the concept. Based on these visits, a U.S. and a European Union patent were filed in 2007. This activity led to exploration of other ideas to pursue. This collaboration is also ongoing.
3. University of Porto, Portugal: Teresa Mata of the University of Porto secured a Fulbright scholarship to work with Drs. Heriberto Cabezas, Douglas Young, and Raymond Smith of NRMRL on environmental process design and integration. She visited Cincinnati twice to conduct this research which became a significant part of her Ph.D. dissertation. Dr. Ray Smith traveled to Porto to be at the Ph.D. defense as the U.S. adviser. During the Phase I of the Pilot, Teresa Mata and Antonio Martins also worked on developing a framework of sustainability metrics working with Subhas Sikdar of NRMRL. Technical publications in peer reviewed journals resulted from both projects. The latter project is still ongoing.
4. The Pilot Study inspired two other NATO ARWs that Subhas Sikdar directed, one on Tools and Methods for Pollution Prevention in Prague in 1999, and the other on Technological Choices for Sustainability in Maribor, Slovenia in 2003. The proceedings were published as books by Taylor and Francis (UK) and Springer-Verlag (Germany) respectively.

Additionally two conferences entitled, Clean Products and Processes were also organized by Subhas Sikdar under the sponsorship of the Engineering Foundation. These were held in San Diego and Lake Arrowhead respectively.

5. Denmark Technological University: Prof. Henrik Wenzel sent two of his students to Cincinnati to work with Dr. Maryann Curran of NRMRL on life cycle assessment methodology development.
6. Ben Gurion University, Israel: Prof. Chaim Forgacs of Israel and Subhas Sikdar collaborated on a proposal for an advanced research workshop (ARW) on industrial water security and sustainability, to be held in Beer Sheva in September 2006. This proposal was not funded by NATO SPS. However, a visit of Subhas Sikdar resulted in an

understanding of developing a collaborative project between the two organizations to conduct studies on multi-functional sorbents.

None of these collaborations could be launched without having the Pilot as a forum for exchanging ideas to solve problems of cleaner production.

USA: Gilbert Rochon, Purdue University, West Lafayette, Indiana

Establishing a Real-Time Remote Sensing for Early Warning & Mitigation of Disasters and Epidemics: The Kamal Ewida Earth Observatory (KEEO)

NPD: Dr. Gilbert Rochon, Assoc. Vice President for Collaborative Research; Director, Purdue Terrestrial Observatory; Chief Scientist, Rosen Center for Advanced Computing, Purdue Univ., USA rochon@purdue.edu

PPD: Prof. Dr. M. Magdy Abdel Wahab, Professor & Chair, Dept. of Astronomy & Meteorology, Faculty of Science, Cairo University, Giza, EGYPT magdy_wahab@yahoo.com

Co-Director: Prof. Dr. Gülay Altay, Director, Kandilli Observatory & Earthquake Research Institute (KOERI), Boğaziçi University, Istanbul, TURKEY

Co-Director: Dr. Gamal El Afandi, COO-Designate, KEEO; Dept. of Meteorology & Astronomy, Al Azhar University, Nasr City, Cairo, EGYPT

Co-Director: Dr. Okan Ersoy, Professor, Dept. of Electrical & Computer Engineering, Purdue Univ., USA

Starting Date: September 1, 2008

Duration of Project: 36 months

Project Description Summary:

This project establishes the Kamal Ewida Earth Observatory (KE Earth Observatory). Dr. Mohamed Kamal Tolba Ewida, until his untimely death on November 4, 2006, ably served as Egypt's delegate to the NATO CCMS Pilot Study on Clean Products & Processes. Dr. Ewida was also Dean of the Faculty of Engineering at Zagazig University, Egypt, and was an early advocate on behalf of environmental sustainability. The KE Earth Observatory will combine the expertise and be a jointly managed initiative of two of Egypt's largest and most venerable institutions of higher learning, Cairo University and Al Azhar University, both based in Cairo, Egypt, a NATO Mediterranean Dialogue country, with established environmental observatories in two NATO countries, Turkey and the USA. The KE Earth Observatory is endorsed by Egypt's Prime Minister's Crisis & Disaster Management Sector, the Ministry of Agriculture's Agricultural Research Center (ARC), the National Authority for Remote Sensing & Space Science (NARSS) & others.

Specifically, the Egyptian partners will engage in applications development, research and instructional collaboration with partnering resources from Boğaziçi University's Kandilli Observatory and Earthquake Research Institute (Istanbul, Turkey), with expertise in disaster mitigation, and Purdue University Rosen Center for Advanced Computing's Purdue Terrestrial Observatory (West Lafayette, Indiana, USA), with expertise in real-time remote sensing and

environmental sustainability. Since the primary focus of the KE Earth Observatory will be the application of real-time satellite remote sensing for early warning and mitigation of biogenic and anthropogenic disasters, including epidemics and epizootics, there are multiple end-users for this project, including the WHO Regional Office, as an ineluctable direct result of the interdisciplinary approach to effective disaster management.

This collaboration, with support from NATO's Science for Peace and Security program, will result in installation of instrumentation to facilitate timely notification, mitigation and humanitarian response to an array of natural and man-made disasters, initially focusing on meteorological disasters (e.g. storms, flooding, drought) and on public health disasters (e.g. epidemics and epizootics). Moreover, the project will facilitate collaborative research on identification of best management practices (BMPs) and decision support, within the Egyptian context, for disaster vulnerability assessment, early warning, crisis management (i.e. in collaboration with government, multi-lateral agencies, NGOs, academe, press and the private sector), environmental impact assessment, emergency response, evacuation, disease outbreak containment, search and rescue, damage assessment and post-disaster reconstruction. Finally, so as to share the benefits of this initiative with a wider audience, the project will develop a web-based Disaster Mitigation Hub, initially accessible, during beta testing, to the initial partnering universities and collaborating end-users, then to additional Egyptian universities (e.g. Assiut University, University of the Suez Canal, Zagazig University and American University in Cairo) and ministries (e.g. Ministry of Environmental Affairs; Ministry of Health), subsequently to NATO members, partners and dialogue countries, and ultimately available to the global scientific community, in order to further the state-of-the-science with respect to disaster preparedness research and instruction, as well as to strengthen collective capacity for anticipation and response to meteorological, environmental and public health disasters.

Slovenia: Prof. Peter Glavic, University of Maribor

Research: The Pilot has stimulated our research in the area of sustainable production and environmental education. The results of the research have been published in five papers in refereed scientific journals, we contributed three chapters to the NATO ARW workshop presentations published in the books printed by Springer in Berlin, and six papers have been presented at scientific meetings and published as conference proceedings.

The focus of the research of UM FKKT in the period 2003-2008 within NATO SPS in sustainable production was proposing indicators of sustainability, which could be used as strategic metrics for identifying more sustainable technological options towards cleaner products and processes. A model for obtaining a composite sustainable development index was designed, in order to track integrated information on economic, environmental, and social performance of a company with time. Also, a systematic approach to the problem of sustainable process synthesis of large-scale chemical processes with respect to the resource usage and other environmental considerations has been developed. Research regarding sustainable development was focused on the possibilities of attaining the zero-waste concept in the case of sugar production.

Environmental engineering education: University sustainability education programmes in several European countries and USA have been compared to find common characteristics of the curricula in environmental science and engineering programmes. Terminology in the field of sustainable development is becoming increasingly important; this has stimulated research to clarify and classify the terms used in the field. The idea of a sustainable university was elaborated and tested at the University of Maribor.

Spin-offs: An international conference on Industrial Pollution and Sustainable Development was organized in Maribor on December 2005. We also took part in the NATO Workshop on Energy Security, Naples, 4-7 July 2007. One of the outcomes of our participation was joint collaboration with Norwegian University of Science and Technology (Norwegian delegate in NATO SPS: Prof. Annik Magerholm Fet) and other European Universities in the EU funded project, Postgraduate school of industrial ecology, Marie Curie conferences and training courses, PSIE - MSCF-CT-2005-029529.

Acknowledgment: The NATO Pilot was co-financed by the Slovenian government in the period of 2003–2008 under the programme of Public Employment for young professionals.

Slovak Republic: Dr. Miroslava Vaclavikova

First time I joined the pilot study on Clean Products and Processes in Cetraro, Italy in 2003, and I have found this study very valuable for Slovak Republic, as well as for my research activities in the field of environmental technologies and also my future professional career.

The Slovakian participation in pilot study resulted in a number of international collaborative projects.

In the frame of CPP, our activities have been focused on:

- a) the study and utilization of wastes/by-products generated by metallurgical as well as power industries as sorbents in water treatment technologies.
- b) the synthesis and development of new nanomaterials based on iron oxides suitable for water treatment technologies, especially for removal of arsenic species from water streams. This research was a spin-off from the Pilot Study and was carried out in cooperation with Aristotle University of Thessaloniki, Greece within the NATO Collaborative Linkage Grant (2004-2006). The study was funded by Ministry of Education of SR in the frame of APVT programme for young aid.

Another spin-off from the pilot is NATO Advanced Research Workshop on Water Treatment Technologies for the Removal of High-Toxicity Pollutants, which was held on 13-16 September 2008 in Kosice, Slovakia. Both co-directors (M. Vaclavikova, Slovakia and K. Vitale, Croatia) have been participants of pilot project. This clearly proves that significant network based on excellent cooperation between participants has been established.

I am very pleased that I had the chance to participate in this excellent study. I have learned a lot with the exchange of experience, information and ideas related to environmental problems and methods of their solutions.

Bulgaria: Dr. Stefka Tepavicharova

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I am a Bulgarian delegate to the **NATO CCMS Pilot Project *Clean Products and Processes***

from 1999. My participation in this project is in a close relation with my personal qualification and scientific interests. The project topic stays in the base and is of special significance for a large number chemical industrial

processes, environmental chemistry and agriculture. It is also of importance with respect to many problems of human health etc.

I found the project useful and very successful. It was one of the most beneficial to me in the field of cleaner production although it was not a research project and not concrete scientific results were achieved. The main advantages of the project were the multinationality and multidisciplinary of the team. This gave the all participants the possibility to share an experience and to enhance the knowledge of clean products and processes, to facilitate communication and exchange of scientific ideas and to have larger view and deep understanding of problems connected to the project topic.

My participation in the project and attendance of the meetings, due to the mobility grants, helped me to realize the importance of the topic for my own country. Thus it became a momentum for creation of few new projects - EC SSA Project *Clean Black Sea Working Group* (Program INCO - 2004-2005 – ICA1 – 2004 – 003510), EC SSA Project *Centre of Multifunctional Materials and New Processes with Environmental Impact* (Program INCO – Centre of Competence 2005-2008–CT – 2005 – 016414), Project *Centre of Technology Transfer-TransMission* (Program PHARE - BG 2005/017-353.10.06/ESC/G/TTO – 09).

In the frame of NATO *Pilot Study project Education and Training in Sustainable Development* my activity was connected with the organization of the Project *Centre of Multifunctional Materials and New Processes with Environmental Impact*. The Center is situated in my own institute. Its priority activities are focused on the ecological aspects of multifunctional materials, sustainable utilization and management of natural chemical resources, clean processes and technologies, etc. In this Center I am working in collaboration with NATO project colleagues from Lithuania, Slovakia and Norway.

In the frame of NATO *Pilot Study project Cleaner Production Policy in Transition Economics* my activity was connected with the organization of the *Centre of Technology Transfer (TransMission)* situated also in my own institute. The Center is networking with NATO project colleagues from Lithuania and Norway.

Colleagues from the NATO project (Portugal, Italy, Greece, Slovakia) are involved as members or as partners in the Project *CLEAN BLACK SEA WORKING GROUP* and work for the idea “European Scientists for Clean Black Sea”.

Turkey: Prof. Aysel Atimtay

I started to participate in the NATO/CCMS Pilot Project on “**Clean Products and Processes**” in 1999. I made an application for the Fellowship Programme of the NATO/CCMS in 1998. Following the recommendation of the Selection Panel of the Fellowships Programme, I was awarded a fellowship to be associated with the CCMS pilot project on “Clean Products and Processes”.

With this fellowship, I was able to participate in 4 annual meetings of the pilot project between 1999 and 2002. Later on, I was able to participate as the Turkish delegate in the later meetings of

the project with the financial support from NATO.

The pilot project was a very useful one. I have benefitted from the project a lot. My specific area of contribution in this project was Clean Energy, Clean Energy Production Systems and Development of New Sorbents for the Gas Cleanup to comply with the regulations. I also made presentations on the color removal from the textile wastewaters by using some novel sorbents and Best Available Techniques (BAT) for Clean Processes.

With my presentations on these subjects during the annual meetings, I also have brought the delegates up to date with the developments on Clean Production applications in Turkey. The presentations from the other countries participating in the project also updated me about what is going on in the other countries. This was a mutual exchange of information, knowledge and expertise on a friendly basis from which everybody benefitted at the end. Since I am a Professor of Environmental Engineering, I have used the knowledge and experience I have gained during this pilot project in my lectures. My students have also learned CPP and benefitted from me.

I volunteered to host one of the meetings in Istanbul, Turkey. The annual meeting of 2006 was hosted by me in Istanbul. It was really a good meeting in which a Special Topical Symposium on **“WATER REUSE AND RECYCLING”** was conducted. Water reuse and recycling is a very important topic in the last decade, especially in the Mediterranean countries. Therefore, in this topical symposium this subject was addressed in time and in great depth with some invited speakers.

A spin-off from this project will be organization of a new Training Course for the Mediterranean Dialog Countries on Water Use and Sustainable Development. A project application will be made to NATO at the end of the summer. The partners for this course will be Prof. Dr. Jose Coca from Spain, Prof. Dr. Farhang Shadman from the USA, and Prof. Dr. Aysel Atimtay from Turkey. The other partners will be chosen from the Mediterranean Dialog Countries.

Finally, the pilot project was conducted very successfully by Dr. Subhas Sikdar and Mr. Dan Murray, the Director and Co-Director of the pilot project.

Czech Republic: Col. Ales Komar and Dr. Frantisek Bozek

The following projects were carried out in the Czech Republic and the following benefits were achieved during and within the solution of the NATO/SPS (CCMS) Pilot Project on “Clean Products and Processes”:

The Regional Centre of Cleaner Production in Brno in conjunction with the University of Defence and the Mendel Agriculture and Forest University in Brno:

Projects	Suggested Measures, Description	Benefits and Improvements
Zvyšování kvality výroby a snižování dopadů na životní prostředí v provozu pekárny.	Installation of flour silos, flour transport in tanks; pneumatic flour transport into bakeries, installing new technology of fermentation process, common	Reduction of dust nuisance at a workplace, reduction of flour consumption, losses and waste flour, elimination of mycotoxins during storing, reduction of the amount of non-consumed

HEPEK s.r.o. Brno	pastry production automation, packaging waste recycling.	pastry, reduction of drinking water consumption and consequently of waste waters, reduction of energy consumption, increase of production hygiene, reduction of packaging waste
Výroba tavených sýrů z hlediska možností čistší produkce. Moonchees Zlín	Reduction of waste water treatment plant pollutant load, installation of smoking room with the friction formation of smoke.	Saving of drinking and technological water, reduction of curd particles escapes into waste waters, reduction of emissions into the air, saving of raw material.
Čistší produkce v zemědělské prvovýrobě. Ledeko Inc. Letovice	Reconstruction of a large-scale cowshed and removal of three cowsheds, construction of a large-capacity dung yard and removal of field dunghills.	Cost of investments: $1,1 \cdot 10^6$ USD, revenues: $2,7 \cdot 10^5$ USD per year, payback period: 8,0 years, smaller weed infestation of fields, lower consumption of herbicides, lower soil compaction, reduction of the consumption of industrial fertilisers and diesel oil.
Optimalizace provozu mlékárny s ohledem na prevenci vzniku odpadů. MILTRA s.r.o. Městečko Trnávka.	Accumulation of whey in storage tanks, building in of the rotary screen filter, recycling rinsing and cleaning waters, cleaning the entire whey conduit lines, cleaning the filter and the accumulation tank.	Cost of investments: $7,2 \cdot 10^4$ USD, revenues: $1,9 \cdot 10^5$ USD per year, payback period: 0,6 year, reduction of waste waters pollution through significant elimination of organic matter, reduction of the total amount of waste waters.
Snížení množství odpadů a energetických ztrát při porážení drůbeže. UKAMO spol. s.r.o. Modřice	Exchanging the obsolete machinery for poultry entrails processing, exchanging the scalding tank for a type with a close circuit and steam turbo-blower, implementing vacuum transport of soft wastes, introducing the air-cooling of poultry.	Cost of investments: $1,6 \cdot 10^6$ USD, revenues: $6,7 \cdot 10^5$ USD per year, payback period: 3,2 years, increases of production yield, reduction of energy demand, water consumption, the amount of waste waters and waste waters pollution through elimination of organic matter, increase of production hygiene, reduction of Salmonella health risks for the consumers of fresh poultry.
Zvyšování kvality výroby a snižování dopadů na životní prostředí v provozu pivovaru. Pivovar Černá Hora.	Installation of pressure tanks in beer and syrup stock, innovation of waste water treatment plant operation, innovation of beer filtration, installation of BAT checking unit with UV and IR check-up.	Cost of investments: $5,9 \cdot 10^5$ USD, revenues: $1,4 \cdot 10^5$ USD per year, payback period: 4,5 years, elimination of the critical point of procedure, reduction of waste waters pollution and total amount of waste waters.

Belgium: Prof. Carlo Vandecasteele and Prof. Chantal Block

The Belgian delegates C. Vandecasteele and C. Block, attended the Pilot study NATO SPS respectively the last 5 and 4 meetings. The different subjects treated during these meetings gave a better understanding of the most important aspects of Cleaner Products and Processes, initiated interesting discussions and brought researchers with common interests together. Beside the

professional contacts a number of friendly relations were established.

In the frame of the meetings in Alesund and Istanbul, partners from Belgium (Katholieke Universiteit Leuven, Universiteit Gent, VOKA Halle-Viloorde, Interleuven), Poland (Technical University Lodz, Boruta Industrial Park) and Romania (Rompetrol Industrial Park, Carfil Industrial Park), established contacts aiming at the improvement of industrial parks in Poland and Romania. They started a two-years project supported by the Flemish Government “*Material, energy and water management in industrial parks: industrial symbiosis*” in January 2008.

Eco-industrial parks are sites where different companies work together, according to the principles of industrial ecology/symbiosis, in order to achieve sustainability concerning process management, site organisation, exchange of materials and of energy, utilities management, waste and waste water management. Design and management of industrial parks is in practice however often limited to the collective organisation of road construction, green services, utilities management and security.

The aim of this project is:

- to document basic criteria/principles with which new and existing industrial parks have to comply in order to be catalogued as eco-industrial park based on the knowledge of the Flemish partners. This will result in a checklist on eco-industrial park design, which may also serve as a tool for reorganising existing industrial parks. Special attention will be paid to the exchange of material (raw materials, waste, waste water) and energy streams (industrial symbiosis) by interconnected companies.
- to develop a tool for data gathering on potential material and energy streams in industrial parks of interest, helping in selecting opportunities for the application of industrial symbiosis.
- to use this tool for data gathering for the selected industrial parks (Boruta, Zgierz, vicinity of the city of Lodz, Poland; Rompetrol Navodari Park, Constanta and Carfil Industrial Park, Brasov, Romania) in order to obtain a number of future scenarios for activities (including innovative ones) according to the principles of industrial ecology. It will be attempted to incorporate the residues from the treatment of domestic waste from the city of Lodz into the Boruta industrial park activities. In Poland this project is complementary to a project on industrial symbiosis, financed by the Polish government.

Situation in June 2008: information on the organization of the park and the interconnection between companies for the three parks involved in the project has been gathered. The processing of the data is in course. From these results a number of scenarios for the organization of the parks, according to the principles of industrial ecology, will be proposed. Contacts between Flemish and Romanian partners were established. The same will be done in the next future for the Polish partners.

The participation to the pilot NATO SPS stimulated scientific research at the K.U.Leuven that led to several scientific papers:

- Mortier R., Block C. and Vandecasteele C., Water management in the steel industry in Flanders, 2007, Journal of Clean Technology and Environmental Policy, 9: 257-263

- Block C., Van Gerven T., Vandecasteele C., Industry and energy sectors in Flanders: environmental performance and response indicators, 2007, Journal of Clean Technology en Environmental Policy, 9:43-51
- Vandecasteele C., Block C. and Van Caneghem J., Cleaner Production in the Flemish Chemical Industry, 2007, Journal of Clean Technology and Environmental Policy, 9:37-42
- Block C., Van Caneghem J., Vandecasteele C., 2007, "Eco-efficiency indicators for processes, industrial sites and regions", "Quality and environmental management, Continue change of paradigms", edited by J. Lewandowski and Z. Wisniewski, Lodz, Poland
- Block C., Van Caneghem J. Vandecasteele C., Environmental performance of industrial companies, sites, installations and production processes, Periodicum Biologorum, submitted

Canada: Prof. Alexander Omelchenko

1. As NATO country co-director, I conducted the NATO Advanced Research Workshop "Modern Tools and Methods of Water Treatment for Improving Living Standards". The ARW was held in Dnepropetrovsk, Ukraine on November 19-22, 2003.
2. A NATO Science Series book "Modern Tools and Methods of Water Treatment for Improving Living Standards" was published by Springer in 2005. Editors: Alexander Omelchenko, Alexander A. Pivovarov and W. Jim Swindall.
3. This book is now being translated into Chinese and will be published by China Meteorological Press in July 2009.
4. In the frames of the Pilot, I conducted studies into environmental heavy metal contamination in terms of health risk factors and sources of contamination such as drinking water, gasoline, paint, electronic wastes, etc. The results of these studies were presented during the Pilot annual meetings in Istanbul ("Efficient Technology for Precious Metals Extraction from Secondary Raw Materials") in 2006, in Porto ("Water-Borne Environmental Cardiovascular Risk Factors: Lead") in 2007, and in Berlin ("Surviving Lead") in 2008.
5. An article "Lead as an Environmental Cardiovascular Risk Factor" was submitted for publication in journal "Periodicum Biologorum" (published in Croatia) in 2008.
6. In the frames of the project "Real-Time Remote Sensing & Environmental Monitoring Centers of Excellence", atmospheric lead contamination over Europe was analyzed. The main conclusion was that, despite unequal atmospheric lead emission by the countries, atmospheric lead deposition is nearly uniformly distributed among the European countries.
7. The studies on environmental heavy metal contamination and its relevance to health risk factors will be continued.

UK: Prof. Jim Swindall, Queen’s University of Belfast, Belfast, Northern Ireland

I attended the first meeting in Cincinnati and while there made a bid to host the second meeting in Belfast. The meeting in Queen’s University, Belfast went ahead and was successful.

I attended every subsequent meeting with the exception of the final meeting in Berlin.

The meetings were very different from normal academic meetings being multidisciplinary. This was a strength and allowed me to make contacts and friends in disciplines outside my own.

The spin offs from attendance were very many and included technology transfer visits to the Ukraine, Israel, Portugal and Spain. I hope that these visits will continue in the future as I have firm invitations to visit Bulgaria, Israel, Romania, Slovakia and Italy.

I am very grateful to NATO for financial assistance to attend the annual meetings and for having the vision to organize these meetings to bring country representatives together to exchange best practice. I have benefited greatly from attendance.

Croatia: Ksenija Vitale, Zagreb

In 2003 invited as a key speaker in Dnepropetrovsk, Ukraine to ARW after joining the CCMS Pilot in Budapest, 2004 and participated until the end in Berlin 2008.

1. Beside many personal contacts, scientific advices, project inspiration,
2. I was guest editor in Croatian scientific journal Periodicum Biologorum (SCI citation), dedicated to the environmental themes and scientists from our pilot participated as authors.
3. in September 2008 with Miroslava Vaclavikova will co organize ARW in Kosice.

Denmark: Prof. Henrik Wenzel

Spin-offs from the Nato/CCMS Pilot Study on Clean Products and Processes

The NATO CCMS/SPS pilot study on Clean Products and Processes Phase I and II has been of tremendous value to me, the two universities to which I have been affiliated and a variety of my research project partners through these 11 years from 1998 to 2008. The lessons learnt, valuable contacts and spin off projects of this pilot study cover topics such as Process Integration, Life Cycle Assessment, Process Intensification, Membrane Filtration, and Industry-University collaboration and have been coined out as co-authoring of articles, mutual hosting of guest professors, PhD students, and master students, editorships of scientific journal, establishment of a permanent PhD course at the Technical University of Denmark, and more. I include a list of spin offs below.

I am truly grateful for having had this opportunity in my professional life.

Collaboration partner	Country	Topic	Comments
Solutia Ltd. - Dr. R. Dunn	USA	Process Integration	Hosting Dr. Dunn as guest professor for two periods in 2000

			<p>and 2001.</p> <p>Development of methodology for Process Integration within the Centre for Industrial Water management. Later applied with great success giving rise to huge saving of water and energy in Danish partner companies.</p> <p>Establishment of a PhD course at the Technical University of Denmark. Ongoing every 2nd year since 2001.</p> <p>Co-authoring 3 articles in J Clean Products and Processes/ J Clean Techn & Env Policy</p>
University of North Carolina - Professor M. Overcash	USA	Process Integration and Life Cycle Assessment	<p>LCA databases on chemicals</p> <p>Co-supervision of master students</p> <p>Co-authoring 1 article in J Clean Products and Processes</p>
Kaunas University of Technology Professor J. Staniskis Dr. Valeras Kildisas PhD student Jolanta Dvarioniené	Lithuania	Cleaner Production, Process Integration, Life Cycle Assessment	<p>Collaboration on a large project on Cleaner Production implementation in Lithuanian paper industry</p> <p>Hosting PhD student, Jolanta Dvarioniené on Process Integration in textile industry.</p> <p>Collaboration on EU workshop on Life Cycle Management</p>
Marmara Research Centre - Post doc Nilgün Kiran	Turkey	Life Cycle Assessment Cleaner Production	Hosting post doc on Life Cycle Assessment and water reclamation and recycling in paper industry
Queens University/ Questor - Director Jim Swindall - Dr. John Stewart	UK	Life Cycle Assessment Industry-University collaboration	Guiding on Life Cycle Assessment and receiving guidance on university-industry collaboration
US EPA - Dr. Subhas Sikdar - Dr. Dan Murray	USA	Cleaner Production and Life Cycle Assessment	<p>Hosting the NatO/CCMS pilot meeting in Copenhagen 2000.</p> <p>Invited speaker on Life Cycle Assessment at NatO/ARW in Prague 1998.</p> <p>US EPA hosting PhD student Gurbakash Singh Bander on Life</p>

			<p>Cycle Assessment tool development in 2003.</p> <p>US EPA hosting PhD student Jesper Kløverpris on Life Cycle Assessment method development in 2005.</p> <p>Subhas Sikdar facilitating membership of editorial board of J Clean Techn & Env Policy</p>
University of Dnepropetrovsk	Ukraine	Process Integration	Invited speaker at NatO/ARW on Modern Tools and Methods of Water Treatment for Improving Living Standards in Dnepropetrovsk, Ukraine
University of Thessaloniki - Dr. Giorgos Gallios	Greece	Wastewater treatment and Cleaner Production	Dr. Gallios hosting a visit to University of Thessaloniki in 2002.
University of KwaZulu Natal, Durban - Dr. Chris Buckley	South Africa	Membrane filtration, Cleaner Production, waste minimisation and Life Cycle Assessment	Inviting Professor Buckley to participate in the pilot and facilitate co-operation with other pilot participants, i.e. University of Calabria, Cetraro, Italy