

Introduction to ICS-UNIDO Activities and Programmes: Focus on Cleaner Technologies and Sustainable Development

Stanislav Miertus*

International Centre for Science and High Technology of the United Nations Industrial Development Organization – ICS-UNIDO - AREA Science Park, Bldg. L2, Padriciano 99, 34012 Trieste, Italy

Abstract

The paper briefly reviews the key issues of the programme which is being developed by the International Centre for Science and High Technology of the United Nations Industrial Development Organization (ICS-UNIDO), focused on technologies for sustainable industrial development and more specifically those applicable to chemical and related industries.

The first part of the paper describes the concept of sustainability with a short overview of the concept of pollution prevention. The second part is devoted to the overview of ICS-UNIDO programmes, with specific focus on catalysis and sustainable chemistry.

Introduction

The United Nations Industrial Development Organization is a specialized agency of the United Nations dedicated to promoting sustainable industrial development in developing countries and countries with economies in transition. It harnesses the joint forces of government and the private sector to foster competitive industrial production, develop international industrial production, develop international industrial partnerships and promote socially equitable and environmentally friendly industrial development.

UNIDO is the only worldwide organization dealing exclusively with industry from a development perspective. UNIDO's services are non-profit, neutral and specialized. UNIDO acts as a catalyst to help generate national economic wealth and raise industrial capacity through its role as a worldwide forum for industrial development and as a provider of technical cooperation services. UNIDO's ultimate goal is to create a better life for people by laying industrial foundations for long term prosperity and economic strength.

The International Centre for Science and High Technology is an Institution within the legal framework of UNIDO with headquarters located in Trieste, Italy.

The Centre's mandate relates to the transfer of

know-how and technology in favour of developing countries, and is justified by the perception that a competitive industrial technological capability cannot be built-up without adequate scientific knowledge and commitment to a sustainable development approach utilizing new and environment friendly technologies.

Concept of Sustainable Industrial Development

The last century was characterized by the positive economic and social results of industrial growth, which have been accompanied by the reversal effect: global environmental crisis. The growing technology-based industry has had an important environmental impact, being the industry the major consumer of natural resources and the major contributor to the overall pollution load. It also accounts for about one third of the global energy consumption of their member states, and for about 10 percent of the total water withdrawal [1]. The relative contribution to the total pollution load is obviously higher for industry-related pollutants (see Table 1) [2,3]. As examples, the industrial sector generates traditional pollutants such as organic substances, CO₂, SO_x and NO_x emissions, hydrocarbons, volatile organic metals (chromium, cadmium, mercury and lead), pesticides and new recognized pollutants (specific toxic substances such as CFCs and dioxins). In particular, four sets of factors are causing environmental problems of global dimensions:

*corresponding author. E-mail: Stanislav.Miertus@ics.trieste.it

Table 1
Environmental impacts of selected industries [2,3]

SECTOR	AIR	WATER	SOIL/LAND
Chemicals (industrial inorganic and organic compounds excluding petroleum products)	<ul style="list-style-type: none"> ➤ Many and varied emissions depending on processes used and chemicals manufactured ➤ Emissions of particulate matter, SO₂, NO_x, CO, CFCs, VOCs and other organic chemicals ➤ Risk of explosions and fires 	<ul style="list-style-type: none"> ➤ Use of process water and cooling water ➤ Emissions of organic chemicals, heavy metals (cadmium, mercury), suspended solids, organic matter, PCBs ➤ Risk of spills 	<ul style="list-style-type: none"> ➤ Chemical process wastes disposal problems ➤ Sludges from air and water pollution treatment disposal problems
Refineries, petroleum products	<ul style="list-style-type: none"> ➤ Emissions of SO₂, NO_x, hydrogen sulphide, HCs, benzene, CO, CO₂, particulate matter, PAHs, mercaptans, toxic organic compounds, odors ➤ Risk explosions and fires 	<ul style="list-style-type: none"> ➤ Use of cooling water ➤ Emissions of HCs, mercaptans, caustics, oil, phenols, effluent from gas scrubbers 	<ul style="list-style-type: none"> ➤ Hazardous waste, sludges from effluent treatment, spent catalysts, tars
Leather and tanning	<ul style="list-style-type: none"> ➤ Emissions including leather dust, hydrogen sulphide, CO₂, chromium compounds 	<ul style="list-style-type: none"> ➤ Use of process water ➤ Effluents containing suspended solid, sulphates, chromium 	<ul style="list-style-type: none"> ➤ Chromium sludges
Paper and pulp	<ul style="list-style-type: none"> ➤ Emissions of SO₂, NO_x, CH₄, CO₂, CO, hydrogen sulphide, mercaptans, chlorine compounds, dioxins 	<ul style="list-style-type: none"> ➤ Use of process water ➤ Emissions of suspended solids, organic matter chlorinated organic substances, dioxins 	-

- Destruction of the natural environment with the resultant loss of the bio-diversity;
- Emission of gases which contribute to “green house effect” of global warming;
- Emission of gases which are causing the destruction of the ozone layer;
- Pollution in water and land surface caused by human and industrial waste.

The resolution of this apparent paradox between the economical development and the environmental global crisis can be addressed by the sustainable development. It implies the agreement on necessary changes in people’s lives and business philosophies, based on economic and technological development, prosperity and the conservation and improvement of the environment. The concept of sustainability lies in integrating economical, ecological and social dimensions into a broad overall system (see Fig. 1). Sustainable development requires harmonization of economic growth with environment conservation and protection [4]. In this way, the three main parts – economy, environment and health of society – can be sustained into the future. According to the United Nations World Commission on Environment and Development, Sustainable Development is “*the development that meets the needs of the present without*

compromising the ability of future generations to meet their own needs”.”

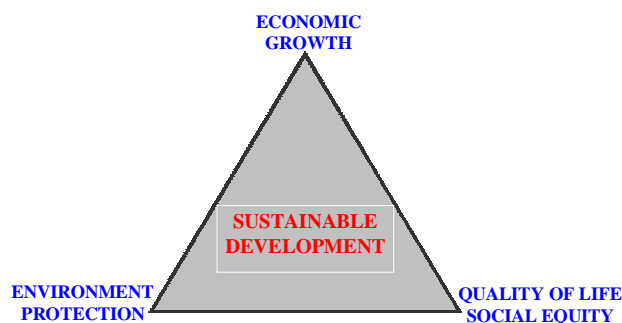


Fig. 1. Three main objectives of sustainable development.

The chemical industry is a key industry that is present in all areas of every day life, such as food and clothing, housing, communications, transport and medicines. In itself, it is a large-scale provider of employment and contributes significantly to domestic economy. However, the chemical industry is also an important source of industrial waste (see Table 2) [5,6]. As an example, in 1993 the U.S. chemical industry produced more than 350 million t. of toxic waste, which were safely disposed of at a cost of \$ 20 billion.

The initial reaction to the chemical waste produc-

Table 2

Waste generation in different industrial segment [5,6].

Industry segment	Product tonnage	Waste generation as kg by-product/kg product
Oil refining	$10^6 - 10^8$	0.1
Bulk chemicals	$10^4 - 10^6$	<1 -5
Fine chemicals	$10^2 - 10^4$	5 - >50
Pharmaceuticals	$10 - 10^3$	25- >100

tion was a reactive approach characterized by increased clean-up activities, in particular “end-of-pipe” strategy, which is the easier environmental solution and implies little modification of processes. Typically, the most common way to reduce pollutant emissions has been to add control technology to bring the process into compliance with discharge standards. However, this alternative is not enviro-economically attractive; although it is effective in preventing direct discharge of waste, it is not preventing and only delaying the introduction of wastes into the environment involving an important cost. One consequence of the “end-of-pipe” approach has been the allocation of large amount of capital to the installation and operation of environmental control equipment.

According to US government data, the chemical industry spent in 1993 \$ 5.4 billion in operating costs to meet government requirements for pollution abatement and control [7]. These data do not include the costs of cleanup areas (hazardous waste sites) and the personnel costs involved in the environmental compliance and reporting.

In this way, the chemical industry spends billions of dollars annually on pollution control and pollutant management. Then, the end-of-pipe strategy is not economic and sufficiently effective to reverse the current environmental trends: the importance of environment protection has increased in the public, political and economic world during the last 15 years, because quality of life is strongly connected to a clean environment. For this reason, the chemical industry is moving towards clean technologies and pollution prevention, showing how improved environmental performance can be achieved while reducing overall costs. Pollution prevention means decreasing the amount of waste or pollution produced in the first place or at source. Resource conservation or increasing the efficiency with which we use raw materials like energy, water and other resources is also pollution preven-

tion. Figure 2 shows the options of waste management within the chemical process. The most important and the most desirable option is the reduction of wastes at the source, which includes housekeeping procedures, changing from organic solvents to water solvent, raw material substitution, change of process operating conditions, cleaner synthesis and production. The following option is recycling or reusing, and the least desirable option is waste treating or waste disposal. Then, the adoption of waste minimization policy implies not only benefit for the environment and the company’s public image, but it also increases benefit in the bottom line since it reduces the costs of waste.

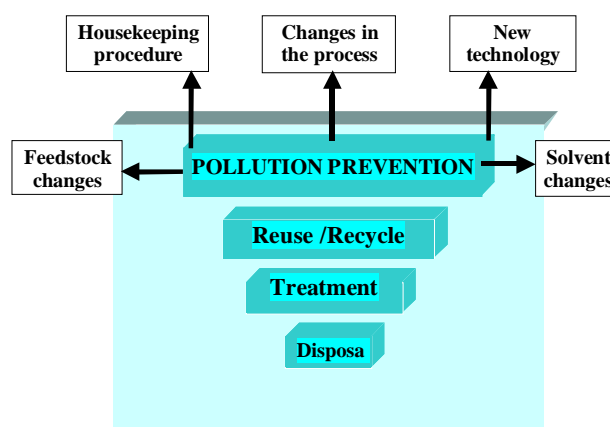


Fig. 2. Waste management hierarchy.

Then, pollution prevention is by far the most economic strategy that enables nations of the world to increase economic growth while maintaining environmentally sustainable development in the past, the protection of environment, health and safety has been viewed as a cost of doing business, of complying with regulations and standards. Today, sustainable development requires that environmental activities be regarded as opportunities for greater efficiency, productivity, quality and reliability. In this way, the sustainable chemistry supports the broader goals of sustainable development, maintaining and improving our quality of life, the competitiveness of chemical industry and the quality of the environment.

ICS-UNIDO Programmes and Activities focused on Sustainable Chemistry

On the basis of the above, the activities of ICS follow an integrated pragmatic approach which include action-oriented research, short-term exchange

between research and technologists in industry, dissemination of scientific and technological information through the creation and management of centres of excellence (focal points), consultancy and advisory services, training courses, scientific workshops, high level seminars, study tours, fellowships, promotion of training arrangements, publication and editing of frontier issues.

In the present work programme the ICS's activities focus to specific sectors within the area of chemistry, environment, new materials and high technology. In selecting the specific subprogrammes and their related activities, special consideration was given to their relevance in relation to the scientific and technological development of developing countries.

Considering that sustainable development depends upon the harmonization of economic growth and environment conservation and protection, the ICS Area of Pure and Applied Chemistry has identified as priority fields in its work programme the following themes, which are of key relevance to economic and industrial development as well as environmental protection:

Remediation Technologies, which are becoming an important and economical way to solve the problem of contaminated and polluted sites, especially in developing countries and economies in transition where the environmental issue has been until recently neglected. New technologies, methodologies and solutions are emerging from various applications and are becoming day by day more economically viable and feasible.

Combinatorial Chemistry and Combinatorial Technologies, which have a strong impact on the development of new chemicals (pharmacy industries, agro-chemicals, new materials). Developing countries need to get acquainted with and gain expertise in combinatorial technologies to help local enterprises remain competitive and economically viable in the coming decades. Combinatorial chemistry and combinatorial technologies have a potential influence not only on industrial growth, but also on environment protection. In fact, by optimising industrial processes and production, with the lowering of relevant costs, less amounts of waste and by-products are created.

Environmentally Degradable Plastics, where the expanding global production and consumption of polymeric materials coupled with increasing public awareness of environmental issues have created serious concern about the problems related to the disposal of plastic waste generated by various sectors of

human activity. Besides recycling, re-use, incineration and composting, new technological developments of environmental degradable plastics contribute dramatically to the tackling of the environmental issue in specific sectors of plastics use.

Catalysis and Sustainable Chemistry, which is an important scientific and technological area for the development of environmentally friendly chemical processes, which in turn form the basis for cleaner industrial technologies development and are also the key elements for an industrial pollution prevention approach. New, less pollutant processes together with the optimisation of existing processes depend to a great extent upon the improvement of catalyst performance in the heavy and fine chemical production lines with a direct impact on the quality and quantity of by-products or waste generated.

Catalysis in the past years has been extensively applied in the petroleum industry, in petrochemistry (synthesis of intermediates and polymers) and in pollutant abatement in flue gas of stationary and mobile energy productions. Nowadays the application of catalysis in Small and Medium Enterprises, especially for the production of fine chemicals and for pollution abatement, has achieved increasing importance and trend.

The problems faced by the chemical industry in the developing countries are high investment costs to develop a petrochemical industry and high costs for the research to develop new products.

On the other hand, the industry of production of fine chemicals require small investments costs and it is focused mainly on the production of intermediates for pharmaceuticals, agrochemical, cosmetics, additives for food and transformation industries.

In many of the developing countries small and medium industries for the production of fine chemicals are already present, however, in most of the cases, they use old processes strongly polluting.

Fine chemical industries are characterized by small plants where, in general, multi-step processes synthesize the products; stoichiometric reactions with expensive and toxic reagents and sacrificial reagents are used with contemporaneous production of toxic wastes.

In these last years a clear tendency has been observed in the fine chemical industry to transform non-catalytic processes into catalytic ones, especially heterogeneous. Heterogeneous catalytic processes enable the transformation from batch to continuous processes and thus realize a one-pot synthesis with lesser

production of waste and avoiding the use of toxic and expensive reagents.

Therefore using heterogeneous catalysis it is possible to transform old processes into new ones increasing the productivity and the quality of the products as well as the benefit for the environment. Moreover new processes can be developed considering local needs of chemical intermediates or local natural products and by-products of other industries with low investments and research costs.

Another key driver of catalysis development is the concept of pollution prevention as the one of fundamental elements of sustainable development. To this respect, several important issues should be approached on a global level, namely the need of reducing, eliminating Persistent Organic Pollutants (POPs) and Persistent Toxic Substances (PTS). In this field, catalytic processes play a key role, not only in the improvement of industrial processes in order to reduce POPs release, but also in new technologies effective in the destruction/elimination of POPs already produced (e.g. PCBs). Another important issue of pollution prevention is the use of new efficient catalysts in automotive transport.

Due to this important role of Catalysis in Sustainable Chemistry, ICS-UNIDO has developed a series of awareness and capacity building activities in this field, namely:

- Scientific Planning and Coordination Meeting on *Catalytic Processes for Petrochemical Industries*, Trieste, Italy, 4-6 December 1996
- Training Course on *Catalytic Processes for Petrochemical Industries*, Cairo, Egypt, 23 November – 4 December 1997
- Expert Group Meeting on *Trends in Catalysis for Industrial Applications*, Trieste, Italy, 27-29 April 1998
- Workshop on *New Catalytic Systems and Processes Applicable to Small and Medium Enterprises*, Bratislava, Slovakia, 28 September – 3 October 1998.
- Workshop on *Catalysis in Fine Chemistry*, Rio de Janeiro, Brazil, 17-21 May 1999
- Expert Group Meeting on *Guidelines on Chemical Technologies Based on Catalysis*, Trieste, Italy, 14-15 June 1999
- Seminar on *New Catalytic Systems and Processes Applicable to Small and medium Enterprises*, India, February 2000
- Expert Group Meeting on *Clean Technologies for the Reduction and Elimination of POPs*, Trieste, Italy, 4-5 May 2000
- Workshop on *POPs Reduction-Elimination for North-East Europe*, St. Petersburg, Russia, 16-19 October 2000
- The Workshop on *Catalytic Processes for Clean Chemistry and Water and Air Depollution*, Hammamet, Tunisia, 19-22 November 2000
- Expert Group Meeting on *Clean technologies for Sustainable Chemistry and Pollution Reduction and Prevention*, Trieste, Italy, 17-18 May 2001
- Workshop on *Catalysis for Environmentally Friendly Processes and Products*, Istanbul, Turkey, 24-27 September 2001
- Workshop on *Catalytic Technologies for Sustainable Chemistry*, Buenos Aires, Argentina, 28-30 November 2001

Another important part of the ICS-UNIDO programme is focused on: project preparation and development, database creation, network and publication activities. More information can be found in the ICS-UNIDO web site at <http://www.ics.trieste.it>

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