
Cleaner Production

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In May 1989, the United Nations Environment Program (UNEP) Governing Council asked UNEP to promote the establishment of a network to "allow the transfer of an environmental protection strategy". This was prompted by a growing realization that the cost of dealing with pollution resulting from human activities, particularly in industry and agriculture, after it has been generated (the so-called end-of-pipe approach) has been increasing dramatically over the years since the Stockholm Conference of 1972. A new approach now emphasized that, rather than wait until pollution is generated, it would be more sensible to attempt to prevent it in the first place.

As thinking moved along these lines, the investigation extended to consider other issues not looked into so far. These covered product design, the materials used to produce it, the production processes, and even the very social environment that created demand for such a product or service. It also became clear that we must continue along this path, always doing better than before, up to the theoretical ideal of zero pollution.

The strategy of cleaner production (note the 'er' in cleaner, and the use of production rather than technology or product) formulated by UNEP to articulate this new approach was launched in a conference in Canterbury in 1990. The strategy is now adopted worldwide and applied in different ways, having shown a remarkable ability to interface and/or assimilate many of the ideas that developed over the last decade or so in environmental management.

FROM POLLUTION ABATEMENT TO POLLUTION PREVENTION

Concern about pollution from modern industry and agriculture in the industrialized countries was the main force behind organizing a United Nations (UN) Conference on the Human Environment held in Stockholm in 1972. This was one of the series of UN-sponsored conferences that dealt with global problems (desertification, water, population, etc.). The Stockholm Declaration at the end of this conference placed pollution at the top of the environmental agenda at the time.

Emphasis in the 1970s was on pollution abatement. Emissions and effluents had to be treated to satisfy certain requirements before being released to the environment. The major industrialized countries were reported in the 1970s to be spending billions of dollars on the control of industrial pollution. In the then Federal Republic of Germany the share of investment in industrial pollution control between

1971 and 1977 was more than 5% of total industrial investment. In Japan, the ratio was as high as 10.6% in 1973, rising to 17.1% in 1975 under the influence of more stringent legislation, before dropping to 5% in the early 1980s. In the USA, the ratio was 5.8% in 1975. The expenditure of private industry on pollution control in some industrialized countries varied between 0.8 and 1.7% of the gross national product (GNP) over the period 1972–1986. On average, countries with the most stringent environmental requirements spent about 1.5% of their GNP on pollution abatement. Of this, the manufacturing sector in the USA and Germany accounted for one quarter of this expenditure, or about 0.4% of GNP. A small number of industrial sectors (chemicals, metal products and machinery) accounted for a large part of this expenditure. As for the split between capital investments and operating costs of pollution treatment equipment, recurrent operating costs were in general, much higher, reaching almost five times the capital expenditures in the USA.

The situation was becoming progressively more serious as new legislation on the use of chemicals was promulgated in the mid-1970s. New industrial chemicals now had to go through stringent, expensive, and time-consuming tests before being marketed. Furthermore, the cost of monitoring compliance to the new requirements was mounting as more personnel, both in industry and in government, became involved in monitoring polluting releases. One estimate is that over US\$ 300 billion was spent worldwide each year on environmental projects, most of which was spent on purchasing and maintaining treatment technologies. With the promotion of the *polluter pays principle* by the Organisation of Economic Co-operation and Development (OECD) in 1975, it was the consumer who foot the bill in the final analysis. This situation could not go on for obvious reasons.

During the latter half of the 1970s the concept of low and non-waste technologies emerged, now shifting the emphasis to pollution *prevention* rather than pollution *treatment*. The 1989 decision of UNEP's Governing Council was perhaps in response to this shift of emphasis. The UNEP Industry and Environment Office in Paris assembled a small core group of experts to work out a program for the implementation of the Governing Council decision.

It is both interesting and instructive to look back at the way thinking of the core group developed as work proceeded. First, they agreed that no justifiable distinction can be made between clean and dirty technology. There is no absolutely clean technology: one technology can only be shown to be cleaner than another. This means that there will always be room for improvement to develop still cleaner and cleaner technologies as time goes on. The ultimate ideal goal is a technology that produces no pollution at all, as if the production process is going on inside a bubble into which raw materials are introduced and out of which come only products (the bubble theory). Further consideration led

to realization of the need to take into account the pollution a product produces as it is being used (e.g., the exhaust gases from a car). Expansion of the scope of the analysis finally extended both ways, downstream of manufacture and use of a product to its disposal as waste; and upstream to the supply side and the pollution produced in extracting and processing the inputs of raw materials and semi-finished goods. Consequently, the investigation needs to address products also, rather than technologies only. It has to extend across the whole life cycle of products (the so-called *cradle to grave analysis*). It has to investigate product design, production process, and management practices. Cleaner production was finally defined as in Box 1.

Box 1 What is Cleaner Production?

Cleaner production is the continuous application of an integrated preventive environmental strategy to processes and products to reduce risks to humans and the environment.

For production processes, cleaner production includes conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes before they leave a process.

For products, the strategy focuses on reducing impacts along the entire life cycle of the product, from raw material extraction to the ultimate disposal of the product.

For services, it incorporates environmental concerns in designing and delivering services.

Cleaner production requires changing attitudes, responsible environmental management and evaluating technology options.

There is more to this compact definition than meets the eye:

1. Cleaner production is defined as a strategy, i.e., it extends well beyond technical fixes.
2. It is an all-embracing integrative view of the issue, that does not isolate and concentrate on one aspect only of the problem.
3. It emphasizes the continuity of the endeavor. We can always do better, *ad infinitum*.
4. The last paragraph means that we have also to look into the social environment that created the demand for this product in the first place, and influenced how it was to be produced.

The complexity of the concept can be more clearly articulated through a hierarchy of substitutions at different levels, taking as an example the motor car:

1. *the process level*: improving the combustion process (combustion chamber design, lean burning, etc.);
2. *the component level*: adding a new component (a catalytic converter to the exhaust pipe, an example of the end of pipe approach);

3. *the sub-system level*: adopting an entirely new technology (the electric car, fuel cells, hybrid engines);
4. *the system level*: adopting a new system (replacing private cars by mass transit, public transport systems);
5. *the value system*: questioning the very premises that created the need for the product (e.g., alternative landscape planning, value systems, work styles).

This hierarchy of substitutions moves the analysis from the purely technical all the way up to the social level, emphasizing the all-embracing, integrative nature of this definition.

UNEP has continued to hold senior level expert group meetings (Paris, 1990; Canterbury, 1992; Warsaw, 1994; Oxford 1996; Seoul, 1998). The meetings take stock of the status of the cleaner production movement worldwide, and review the work of an increasing number of specialized working groups that provide practical technical advice in application of the cleaner production concept as well as in policy formulation, and design practices.

THE CLEANER PRODUCTION STRATEGY IN PRACTICE

On the practical level, it is claimed that a review of the results of applying the cleaner production approach in 500 case studies of industrial firms has shown 70–100% reductions in some air emissions, water discharges and of the production of hazardous and non-hazardous solid wastes, and that the payback period was quite short, ranging from 3 years to less than 1 year. The late 1980s saw an increasing number of programs in many industrial countries, east and west, based on the cleaner production approach outlined above. One pioneering project in Europe is the Project on Industrial Successes with Waste Prevention (PRISMA) initiated in 1985 by the Netherlands Organization of Technology Assessment. When the preliminary results of field research started in 10 companies in 1988 became available, no less than 164 prevention options were identified. These included minor changes in procedures and installations as well as drastic innovations in products or processes. In 30% of the cases these changes were in the category of good housekeeping; another 30% in material and raw materials; 30% in changes in equipment; and the rest in process modifications (Sybren de Hoo *et al.*, 1991). Some good housekeeping measures effected 25–30% reductions in chemicals used. In a number of companies, technological changes resulted in reductions in waste and emissions of 30–80%. Occasionally, it was possible to eliminate a noxious waste flow completely. The use of alternative raw materials resulted in a 100% reduction in emissions of substances such as cyanide (in zinc plating) and solvents (in decreasing parts).

The cost-benefit analysis showed a heterogeneous picture with a few extremely favorable peaks. In one extreme case an investment of DFl 2500 saved the company DFl 124 000 *per annum*. Another company recouped an investment of DFl 800 000 within a year (saving more than DFl 1 000 000 *per annum*). Of the 45 options actually implemented by then, 20 turned out to be cost saving, and 19 to be neutral. It was found, moreover, that these measures had further indirect benefits, such as improvement in product quality.

Within EUREKA (the co-operative research program in Europe), the EUROENVIRON program began promoting Preventive Environmental Protection Approaches in Europe (PREPARE) in 1990 on the basis of the Dutch PRISMA project. PREPARE sought also to catalyze industry/government cooperation and the transfer of information of pollution prevention and cleaner production.

In the United States, prevention teams have been in operation for some years as part of the "Technical Assistance Program", helping small businesses in adopting pollution prevention technologies. Groups of external consultants assist industrial firms in formulating and implementing a pollution prevention program. Evaluation of their work indicates that these programs were not only commercially profitable and environmentally beneficial, but also useful at the macroeconomic level, as well as helpful in clarifying gaps in current knowledge and identifying areas for research.

Mexico and Brazil have achieved some noteworthy successes in organizing efforts for pollution control at various levels of government. The program in Cubatao, home of a large industrial complex in the state of São Paulo in Brazil, is one important example of a unique institutional system. Enforcement powers were delegated by contract to the Environment Management Company and an integrated control approach was started in 1984. Some of the results achieved by the end of 1989 in air pollution abatement are summarized in Table 1. Similar success was also achieved in reducing water pollutants.

In China in the early 1990s, UNEP, with funding from the World Bank, joined hands with the National Environment

Protection Agency (NEPA) to promote cleaner production throughout China.

In 1993, when the preparatory phase was completed, substantial economic and environmental benefits were identified, even at this early stage of the program:

- Sixty-seven cleaner production options, ranging from managerial changes to process modifications were implemented. Most of these were of the low-no cost type.
- Over US\$ 350 000 saving was achieved for investment of less than US\$ 16 000.
- An average of more than 50% of the chemical oxygen demand in the waste water was eliminated.

In the latter phases, experts were trained to carry out cleaner production activities throughout the country, particularly in small and medium enterprises (SMEs). General and sector specific manuals were published and policy studies carried out. This program has resulted in a gradual shift from investment in end-of-pipe equipment to integrated cleaner production approaches throughout the country.

Many other initiatives in East Europe, the Mediterranean Basin, India, South East Asia, and in Africa could also be cited. The United Nations Industrial Development Organization (UNIDO) cooperated with UNEP in establishing national cleaner production centers (NCPCs). The first batch of eight NCPCs were started in 1994 with funding from European donors and located in Brazil, China, Czech Republic, India, Mexico, Slovak Republic, United Republic of Tanzania and Zimbabwe. NCPCs are spreading gradually worldwide with self-financing in some countries and funding from donors in most cases (Tunisia, Vietnam, Costa Rica, Nicaragua, Croatia, El Salvador, Guatemala and Uzbekistan). A review carried out in July 1998 states that during the period from 1994 up to July 1998, 405 plants participated in in-plant assessments, 1016 consultants and participants were trained, 16 000 persons participated in seminars and more than 7700 attended workshops. The review summarizes the main lessons learnt as:

- A 5-year period is necessary to develop a NCPC into a service-oriented unit.
- A system of certification would enhance the status of cleaner production experts.
- Cleaner production can easily be incorporated into and promoted by other related bodies, such as environmental management systems (EMS) or ISO 14000. (UNEP/International Chamber of Commerce (ICC)/Fédération Internationale des Ingénieurs-Conseils (FIDIC) EMS Training Resources Kit explains the relationship between EMS/ISO 14000 and cleaner production).

Table 1 Reduction in atmospheric pollution in Cubatao, Brazil

Pollutant	Initial emissions in July 1984 (kg day ⁻¹)	Emissions in December 1989 (kg day ⁻¹)	Actual reduction (%)
Particulates	316 350	77 949	75
Fluorides	2620	400	85
NH ₃	8736	205	97
NO _x	61 085	47 561	22
HC	90 000	11 970	86
SO ₂	78 353	49 527	37

- While the methodology of cleaner production is applicable to all industrial sectors, sector-specific technical expertise needs to be developed.
- An integrated program, rather than a project approach is necessary for sustainable cleaner production implementation.

After almost a decade since the launch of the cleaner production program by UNEP, it is useful to take stock of past experiences and to look ahead into the future:

- There is no doubt that cleaner production has gained remarkable popularity over a short period of time. This is mainly due to the fact that launching cleaner production coincided with a paradigm shift in pollution management from end-of-pipe treatment to pollution prevention. It may seem to have taken a long time to apply the time-honored principle, *prevention is better than cure* but we had to deal with the natural resistance to changing established practices in a functioning

establishment. In good economic times, the costs of end-of-pipe treatment could be easily absorbed with other costs. Furthermore, there were no compelling reasons to internalize environmental costs in the total cost of products. It must also be admitted that regulations in the 1970s and early 1980s focused on end-of-pipe solutions and offered few incentives to pollution prevention initiatives.

- In newly industrializing countries and developing countries, weak monitoring of compliance with environmental regulations, and enforcement mechanisms, mitigated against adoption of cleaner production practices. One could also cite the reluctance of most banks to fund cleaner production projects, due to lack of experience in financial risk assessment of environmental projects.
- However, cleaner production received a tremendous boost once demonstration projects provided concrete evidence of the economic advantages of a host of simple low–no cost actions as mentioned earlier. Pollution prevention came to be considered as a win-win policy.

Box 2 International Declaration on Cleaner Production (adopted at Fifth International High-Level Seminar on Cleaner Production, Korea, 1998)

We recognize that achieving sustainable development is a collective responsibility. Action to improve the global environment must include the adoption of more sustainable production and consumption practices.

We recognize that cleaner production and other preventive strategies such as eco-efficiency, green productivity and pollution prevention are preferred options and require the development, support and implementation of appropriate policies and practices.

We understand cleaner production to be the continuous application of an integrated, preventive strategy applied to processes, products and services to reduce risk and to pursue economic, health, safety and environmental benefits.

To this end we are committed to:

Transparency sharing our cleaner production experience:

- by fostering and promoting dialogue on the implementation of this strategy;
- through communication of the benefits to external stakeholders.

Integration encouraging the integration of preventive strategies:

- into all levels of our organization;
- through EMS, and tools such as environmental performance evaluation, and cleaner production, environmental impact, and life cycle assessments.

building cleaner production capacity:

- by developing and conducting awareness, education

and training programs to facilitate the practice within our organization;

- by encouraging the inclusion of the concepts and principles into educational curricula at all levels.

Creating innovative solutions:

- by promoting a shift of priority from end-of-pipe to preventive strategies in our research and development policies and activities;
- through the development of products and services which are environmentally efficient and meet consumer needs.

Leadership using our influence:

- to encourage the adoption of cleaner production and sustainable consumption practices through our relationships with stakeholders.

Implementation taking action to adopt cleaner production:

- with continual improvement by setting challenging goals and regularly reporting progress through established management systems;
- by encouraging new and additional finance and investment in preventive technology options, and promoting cleaner technology cooperation and transfer between countries;
- through work with UNEP and other partners and stakeholders to support this declaration and review the success of its implementation.

The 3Ps, which stood for the polluter pays principle in 1975, now stood for pollution prevention pays. Several transnational corporations mainly in the chemical industries, announced their unilateral commitment to reduce the pollutants they discharge by fixed amounts over specific time horizons. Eventually, the law of diminishing returns showed that there is a limit which is reached when the easy, low–no cost options are exhausted. Du Pont revived Pareto's 80/20 principle pointing out that the challenge facing management is to identify the actions that account for the first 20% of costs that achieve maximum environmental benefits.

- Most developing countries still have a long way to go, reaping environmental benefits together with economic benefits through relatively simple, short pay-back periods, low–no cost options. What they now need is the local expertise, enlightened management and relatively small upfront financing of the more complex options that have proven economic benefits. Demonstration projects in developing countries continue to show that application of cleaner production practices, more often than not, yield immediate unmistakable economic and environmental benefits, particularly in SMEs. Unfortunately, and for obvious reasons mentioned earlier, this is exactly where cleaner production has not yet penetrated on any significant scale. Positive technical/financial support on an adequate scale is necessary. Such intervention is cost-effective and arrangements could, and have been, concluded with enterprises to pay back part, if not all, of the resulting savings to cover the cost of implementation.
- Cleaner production has stood the test of time. The original definition has demonstrated its compatibility with, and even ability to take under its wing, new ideas in sound environmental management (e.g., eco-efficiency, resource accounting, sustainable consumption, ISO 14000 standards or life cycle assessment and eco-labelling, etc.).
- Although cleaner production has become something of a buzz word in common use, there are clear signs

that it is often used in restricted senses that deprive it from its all-embracing advantage. The most common form of misuse is equating it to pollution prevention particularly in production processes. Perhaps the social aspect of consumption patterns is the one field that has not yet been investigated in depth in operationalizing the definition formulated by UNEP a decade ago.

- With the launch of the International Declaration on Cleaner Production (Box 2) cleaner production has entered a new phase, aimed at creating a multi-stakeholder partnership. It is hoped that this will increase proper understanding and awareness of cleaner production, as well as increasing demand and renewed commitment of cleaner production practitioners. Led by the UNEP Executive Director and the Korean Environment Minister, 64 ministers, CEOs directors of environmental agencies, NGOs and academic institutions signed the Declaration which continues to have more signatories.

FURTHER READING

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