

Cleaner production as a means for effective environmental management

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Abstract

Cleaner production is a strategy to prevent emissions at the source and to initiate a continuous preventive improvement of environmental performance of organizations. In terms of Cleaner production the focus of management should be on prevention rather than on cure in avoiding environmental problems. The inclusion of commitment to prevention in the environmental policy is one prerequisite of the standard ISO 14001. But how can a formalized environmental management system help to start a process of continuous improvement and voluntary self regulation? We conclude from our experience that Cleaner production and ISO 14001 go well together and support each other in helping an organization to really decrease its environmental effect. Analysing environmental management systems introduced on the basis of Cleaner production projects demonstrates, that Cleaner production supplies management and employees with systematic tools to decrease the environmental impact and at the same time save costs from inefficient use of materials and energy and motivates the organization as well by creating awareness throughout the enterprise. © 1998 Elsevier Science Ltd. All rights reserved.

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1. What is Cleaner production?

Cleaner production is a preventive strategy to minimize the impact of production and products on the environment. The principal actors of Cleaner production are the companies, which control the production processes. They are influenced strongly by their customers (private, public or other companies) and politics (by laws, regulations, taxes). Projects which foster Cleaner production in Austria focus on the implementation of the philosophy and the triggering of changes in companies.

The main focus is always to create awareness for the prevention of pollution, to find the source of wastes and emissions, to define a program to reduce emissions and increase resource efficiency by implementing and documenting Cleaner production options.

According to the interdisciplinary Cleaner production approach a range of options can be used, including:

- good housekeeping with materials and energy

- training of employees, better logistics, improvement in data availability and the communication between departments
- substitution of raw and auxiliary materials with less harmful ones or ones that can be used more efficiently or can be recycled internally or externally
- modifications of products to eliminate production steps with large environmental impact
- process modifications to minimize waste and emissions
- internal recycling
- introduction of waste into external recycling networks

Cleaner production contributes to the model of sustainable development on a company level. The most famous definition of sustainable development was given in the Brundtland report in 1987. Sustainable development considers the necessities of present generations whilst taking into consideration the needs of future generations. Sustainable development does not allow an economy which wastes resources, which uses non-renewable energy, or which destroys valuable natural capital. This development can be characterized by the following guiding principles [1]:

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From →	To
Throughput economics	Material flow management
Waste of materials	Productivity of materials
Waste of energy	Energy efficiency
Product orientation	Service orientation
End of pipe environmental protection	Preventive environmental protection
Consumption of natural capital	Sustainable use of natural capital
Dominating nature	Orientation at nature
Throw away mentality	Respecting and appreciating mentality

By introducing material and energy flow management into the companies instead of end-of-pipe measures, Cleaner production aims to avoid wastes and emissions and use materials and energy as efficiently as possible. Our group has been active in the Ecoprofit and Prepare projects in Austria for six years now. The projects included companies from the textile, pulp and paper, food processing, machine building, wood working, printed circuit board manufacturing and galvanizing industries covering all the sectors and sizes, well over 100 companies in Austria by now [2–4].

In these projects the methods and tools, which were refined in the Austrian Prepare project [4] and the Ecoprofit project with the City of Graz [2] were used. As a first step a systematic balance of all the inputs and outputs of a company is conducted. Then wastes and emissions are traced back to their respective source.

The companies cover technological and organizational problems as well and consider waste and emissions to the atmosphere and water bodies. The weak points and inefficiencies of material and energy use are identified and options for improvements, both economically and ecologically, defined. Consequently, modifications to products and production lead to a situation with less waste and emissions [4]. The systematic analysis of a company in all its aspects, its accounting and costing calculations, its technology, the training of its employees and its legal boundary conditions makes it possible to develop a company specific strategy to increase the efficiency of material and energy consumption and the prevention of emissions and environmental effects.

In projects like Prepare a company works together with a consultant to increase the efficiency of the consumption of materials and energy by organizational and technological innovations. The solutions will always

have to be worked out specifically in the company. Experience shows that external consultants can introduce new impulses into the project and are not hindered by prejudices. At the same time it is useful to include employees of different company divisions — accounting, technology, data processing, purchasing, sales, environment — into a pollution prevention team to get a broad picture of the problems and collect all the necessary data available in the corporation.

The model Ecoprofit of the city of Graz and Stenum uses a different methodology [2]. The basis of the model is the cooperation of companies, the City of Graz and a consulting company. The program consists of the following components:

In a series of nine workshops which are conducted month by month, company representatives learn the approach and apply the ideas in their companies. At the end of this program an award is granted to all the participating companies which

- comply with environmental law
- develop a company specific environmental policy
- implement measures to actually decrease environmental effects
- have an environmental program

The workshops deal with the following topics:

- motivation and information of the corporation
- emissions and their prevention, environmental costs
- design of a company specific environmental program
- material flow analysis
- waste logistics, handling of hazardous materials
- legal aspects
- energy analysis
- environmental controlling
- preparations of a company report and for the award

Regular discussion among the companies in the workshops fosters continuous work in special areas and the implementation of options. Additionally, new solutions can be found and ideas initiated. Parallel to this series, experts from the consulting team visit the companies in between the workshops and give their input.

This approach has proven successful over five years. It fosters the idea of self-help and so builds a solid basis for a continuing process. Moreover, it creates a network or a club of companies pursuing a sustainable development in a geographical region. Furthermore, it is comparatively cheap for the companies to participate and does not require a huge budget from the City at the same time. Especially for this program, recognition has been worldwide: similar programs have been done in three more cities and regions in Austria, in the cities of Decin and Zlin in the Czech republic, for the cities of Martin and Trnava in the Slovak republic and in two cities in Brazil.

In all the projects, emissions could be reduced sig-

nificantly. In a machine producing company the project aim for the reduction of solid waste was defined by: ‘half is enough’. The project resulted in a 60% reduction of solid wastes. The same is true for at least four more companies. The COD of waste water could be reduced by 25 to 40%, the water consumption and the waste water amount also.

One company, only by better servicing its fat separator and by proper cleaning could reduce the COD by 50%! Solvent use for painting generally could be reduced by 20–50%. Also the consumption of energy could be reduced up to 40% in some companies, especially if drying operations are employed.

All in all projects typically give a net benefit of 0.5–1.5% at a payback time of approx. 1–2 years. Numerous solutions have been implemented, saving literally millions of Austrian schillings in some plants, annually. The company leaders now know their processes better than before; the work has stimulated innovations. The companies can also use the results of their work for improving their public image and marketing.

Fig. 1 shows the results from a Cleaner production consulting project with 13 Styrian companies conducted in 1994 and 1995. These results are typical of the findings from the other projects. Almost half of the options found in the projects were not technical ones, but organizational ones and good housekeeping! They involved purchasing, the formation of environmental teams where there were none, waste separation, handling of chemicals and waste. Moreover, most of these options were already known to the operators and they only had to be collected systematically, evaluated financially or presented to the management [4].

The projects showed a need for a systematic approach to network information from different stages of the production process. The solutions also often require the

cooperation of suppliers of raw materials and equipment, producers and customers.

Cleaner production is a process that takes time, as it involves organizational, as well as technological, changes. It is not enough for consultants to locate the technological options: they also have to be effective catalysts in a process that changes attitudes and organization. Leadership of the management is a prerequisite for successful pollution prevention projects.

Proper organization of the environmental aspects of management is also important for another reason. A Cleaner production project will always come to an end. However, we should find ways to make pollution prevention a part of the companies’ culture and everyday life.

Scheck [5] has shown, analysing the case studies described by Fresner [4] 18 months after their completion, that especially in bigger companies (more than 100 employees) it is difficult to guarantee that good housekeeping measures survive. Creating responsibilities, introducing formal information, documentation, training and working instructions can alleviate this problem. From an organizational point of view, this means that we must introduce Cleaner production into the companies’ management systems.

2. What is ISO 14001 and what is EMAS?

ISO 14000 is a series of voluntary international standards covering environmental management tools and systems. It will ultimately include 20 separate standards covering everything from environmental labelling to assessing life-cycles of products. ISO 14001 is the first standard in this series. It provides specifications with guidance for use for environmental management systems [6].

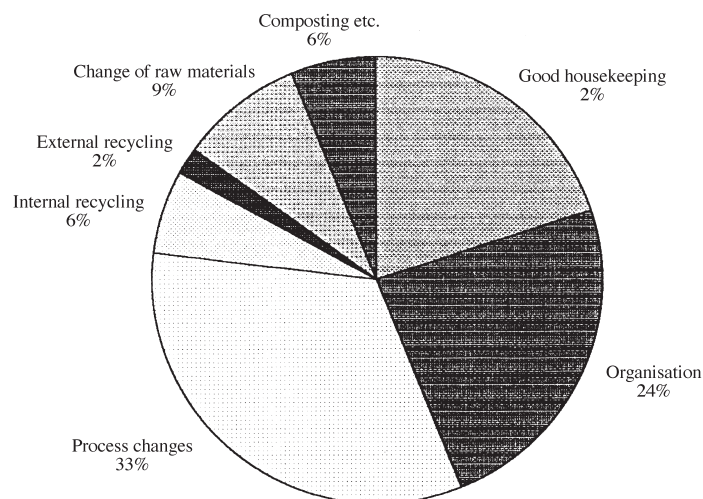


Fig. 1. Classification of options from a Cleaner production consulting project with 13 companies in Styria [4].

It is the standard a company will use to establish its environmental management system and to integrate environmental management with overall business management activity. ISO 14001 tells an organization how to

- establish a disciplined system for achieving stated environmental objectives that adhere to relevant legislative and regulatory requirements
- perform according to its policies and procedures, and
- audit of the system, ensuring full conformance and continual improvement

Elements required in effective management systems are considered to be:

- environmental policy, including a commitment to pollution prevention and a commitment to meet all applicable legislation and regulations
- review of environmental effects
- registration of and compliance with legal requirements
- objectives and targets
- environmental program
- organization and responsibilities
- training
- communication
- documentation
- procedures
- emergencies
- measurements
- correction and prevention
- records
- auditing
- evaluation by top management

An environmental management system is “the part of an overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing, and maintaining environmental policy.” The standard also insists that an organization identify and put in place a system to manage significant environmental impacts of its activities, products or services. However, it does not define what ‘significant’ impacts are or which methods should be used to determine them. It leaves it up to the organization to evaluate its impacts and set priorities in a systematic and documented way.

Reference to pollution prevention is given in two major aspects: The standard demands, that the environmental policy of a company shall contain commitment to continuous improvement and the prevention of environmental effects of the organization. The environmental targets and goals of the organization have to conform to the environmental policy, including this obligation for prevention of environmental effects. The extent to which an environmental management system delivers preventive results will clearly depend on the

extent to which the idea of prevention is incorporated into the policy and the national legislation.

The EMAS scheme (Environmental Management and Auditing Scheme), according to regulation 1836/93 of the European Community creates a common European system in which companies can participate, if they: develop an environmental policy; introduce an environmental management system and produce an environmental statement, analyse their important environmental effects, and demonstrate the basics of their environmental management system and their environmental program. An external certifier then checks this statement. If it holds valid, the company is registered as taking part in the EMAS. The regulation leaves it to a great degree up to the organization of the company which elements are needed for an effective environmental management system.

Positive effects of the introduction of an environmental management system are:

- legal compliance
- reduced risk
- documentation of environmental performance
- motivation of employees

Financial effects can also be pronounced: one of the first companies in Austria which introduced an environmental management system now pays 1% less interest rates and 30% less insurance fees, because the risks of this company are estimated lower by the bank and the insurance company [7].

The two-level-model of environmental management system in Fig. 2 shows how the organization of the company acts to minimize the environmental effects, wastes and emissions of the firm.

Management controls the flow of materials and energy in, within and out of the company during regular and abnormal operation. For this, they need information on the materials and energy used (input, output, consumption in the processes). This information is matched with the objectives and targets which are derived from the environmental policy and information on the legal requirements and on the development of technology.

The management influences the employees by training and motivating them or by giving them working instructions. It also organizes maintenance and prevention of problems with the plants and the use of best available technology applicable in the company. The introduction of an environmental management system can be a chance to create the necessary framework for continuous improvement and for the introduction of preventive environmental protection into the company’s management system. So the impact of the organization on the environment can be reduced continuously [3].

With a good environmental management system the management should have no problems in answering the following questions:

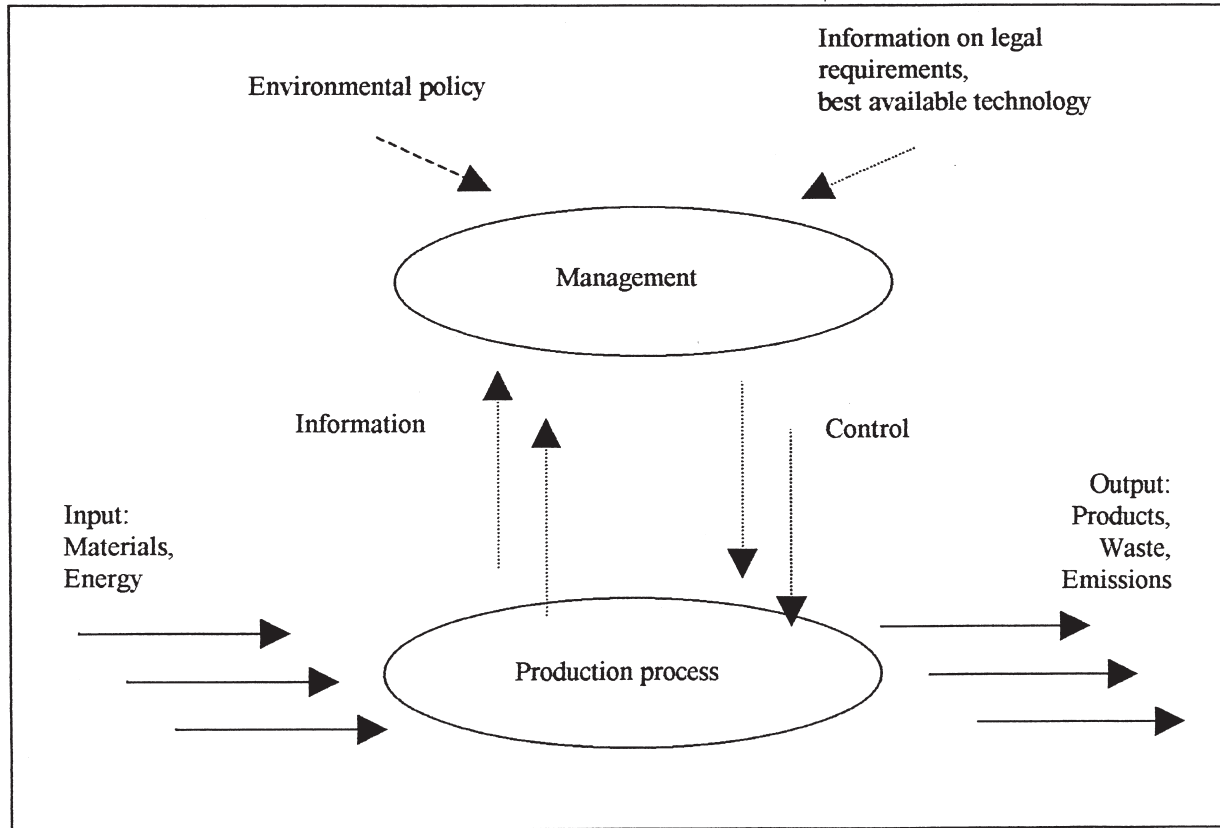


Fig. 2. Model of an environmental management system.

- What is your environmental policy?
- How do you determine the environmental effects caused by your organization?
- How do you make sure that your organization complies with current environmental law?
- How do you make sure that your organization is completely informed about new environmental legislation?
- How do you make sure that the best available and economically sound technology is used to avoid environmental effects?
- Does your pollution prevention program work?
- Does your planning and budgeting process include environmental responsibilities and needs?
- How do you make sure that your employees are trained for their responsibilities?
- How do you make sure that your employees and you are informed adequately about environmental effects?

It seems obvious, that not the certificate itself is the aim, but a living system which reduces the environmental impact of a firm efficiently. How can an effective environmental management system be introduced? For this the preventive strategy of Cleaner production is well suited.

3. Our experience with ISO 14001 and EMAS

We have introduced environmental management systems in 11 sites so far (Table 1). In the first projects (Erste Obermurtaler Brauereigenossenschaft, Steweg, ESG and Eurostar) we cooperated with another consulting company from Graz, Infora. The Erste Obermurtaler Brauereigenossenschaft was the first company in Austria to introduce an environmental management sys-

Table 1
Environmental management systems introduced by Stenum (basis April 1997)

Company	Year	Sector
Erste Obermurtaler Brauereigenossenschaft	1995	Brewery
Steweg (Mellach, Graz, Werndorf, Pernegg)	1996	Steam power plants
ESG-Linz (Two sites)	1996	Steam power plants
Eurostar	1996	Car assembler
Alfred Wall AG	1996	Printer
DI Robier Bau GmbH	1996	Construction company
Leopold Pharma	1997	Pharmaceutical company

Table 2
Current projects (basis April 1997)

Company	Country	Sector
Dunapack	Hungary	Paper mill
Purator Hungaria	Hungary	Engineering company
Köbanyai Sörgyar	Hungary	Brewery
Znovin Znojmo	Czech republic	Vinery
Berglandmilch GmbH	Austria	Dairy
Knaus	Austria	Joiner
Heuberger GmbH	Austria	Anodizer

tem. Table 2 shows the current projects. They include companies in Hungary and the Czech Republic.

We use the following approach for the introduction of an environmental management system (Fig. 3).

First, the environmental policy is defined. In this process the consultant assists with his knowledge of the company and its environmental problems. Then parallel working groups make a detailed initial review of the environmental performance of the company producing a register of laws and regulations relevant to the company. Today there are more than 100 federal laws and regulations in effect in Austria concerned with environmental affairs [8]. After this an actual input/output analysis is made. This analysis is not demanded by ISO 14001, but it has proved to be an effective basis for environmental controlling. The organization of the company is analysed for the existence of the elements of ISO 14001. Existing elements e.g. of other management systems, e.g. ISO 9000 are included. By the introduction of the planning process to identify and eliminate digressions from the policy and from legal compliance, the wheel of continuous improvement is started. This process then is documented in a manual with working instructions for

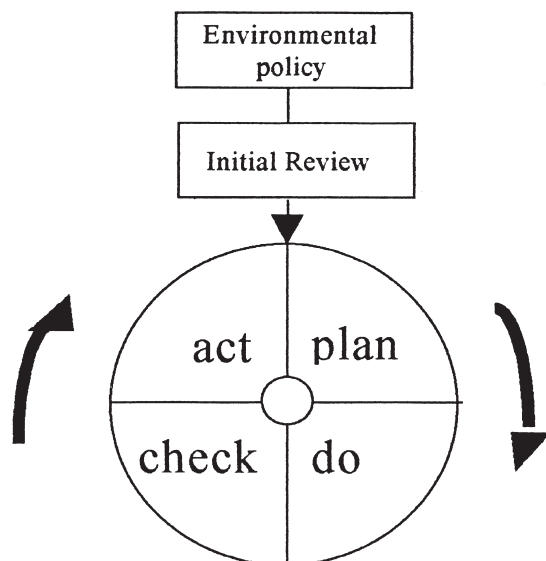


Fig. 3. The introduction of an environmental management system.

important activities (environmental controlling, purchasing, planning, operation of plants, handling of chemicals, auditing).

The actual work is done in working groups of two to five, usually each one headed by a member of the environmental team. Together they develop the elements which have been specified during the first review in the first environmental program together with the consultants. They describe the actual practice within the company themselves and only add what is missing. By this, an active system is generated, which guarantees the cycle of planning the environmental performance and measures to improve it, introducing the measures, checking the performance and refining the systems elements, where necessary. The program involves many employees and motivates them to act according to what was self defined. Usually, many creative and innovative ideas result from this process.

Some lessons learned from these projects are given here to highlight key points in the introduction of environmental management systems:

- The importance of an environmental policy addressing the relevant impacts of the company.
It is important that the organization develops an honest policy which addresses the actual situation of the company. The development of a vision needs emotional involvement of the employees [9]. Otherwise, the policy has no motivational power and will be accepted by many employees only as a sheet of paper.
- Quantitative description of material flows
In a company it was discovered during the collection of data for an input/output analysis that their workshop used more than 150 different chemicals, solvents, and sprays. It was not only hard to keep stock, but also very complicated to define proper storage and handling instructions. So they decided to reduce the number to 30. This proved possible, reduced the risks involved and saved storage room and money for unused chemicals which were disposed of from time to time.
- The importance of training
In one Austrian company with 200 employees an intensive training program was carried out, involving literally all the employees in the production. In small workshops, the environmental manager discussed the environmental policy with groups of seven to ten employees, and then together they worked out the relevance of this policy for their work places. During this program more than 70 options for technical and organizational improvement were raised, although the company had done a Cleaner production program before resulting in significant savings of water, energy, and raw materials.

4. Comparing the elements of a Cleaner production program and ISO 14001

After a Cleaner production project, the following elements of an environmental management system are in place:

- environmental team
- environmental policy and aims
- description of environmental effects
- first environmental program
- legal compliance audit

The following tools for controlling the environmental performance are developed during a Cleaner production project:

- evaluation of materials and processes
- energy analysis
- material flow analysis
- use of indicators

Widenmeyer [10] did a comparison of the introduction of an EMS into a company which had prepared itself by a Cleaner production project and one that did not. He concluded that the latter, equally, had to create the fundamental elements of a Cleaner production program: an input/output-analysis as a basis of a register of the environmental effects and of the environmental program and the creation of the position of an environmental manager and an environmental team. The description and documentation of best available technology and the discussion of the actual situation in the company in relation to this is an important part of a Cleaner production project. The description of material flows, where legislative rules apply is equally important to document the legal compliance.

A Cleaner production program will mainly deal with the regular operation of the company. Abnormal business (especially emergencies, fire) might not get the attention it deserves in a Cleaner production project.

Many steps of a Cleaner production project coincide with the needs of an environmental management system. Cleaner production gives a basis for the development of an environmental management system and an environmental information system, as is demanded by ISO 14001 (Table 3). Cleaner production projects usually exceed the demands of the standard in some respects regarding the methodological approach of an input/output-analysis, the systematic documentation of weak points, the extended view of environmental costs and the immediate application of change. These are the points in which a Cleaner production project usually relieves avoidable environmental impact and at the same time unnecessary cost from the company. Cleaner production therefore is a good preparation for the introduction of an environmental management system, but there still remain some requirements to fulfil [11].

Primary differences are based on the degree of documentation: Cleaner production starts with a holistic optimization of the companies production processes in mind. Technical as well as organizational processes are researched, weak points identified and options for improvement generated. So the analysis deals equally with technical and management problems. The documentation of environmental effects and of the environmental policy of the company and of responsibilities is done with a focus on processes and the project, mostly also focused primarily on the weak points. For an environmental management system the documentation has to include environmentally relevant procedures for all departments of the company efficiently.

In addition, there are three more important differences:

- In Ecoprofit, the companies define their environmental policies. This is not the case in other Cleaner production projects. The same is true for the environmental statement. For obtaining certification according to ISO 14001, a written environmental policy must be prepared and published within the company. For EMAS, an environmental statement must be available to the public.
- In a Cleaner production project there is no formal qualification of internal auditors. The process of auditing the management system is introduced only during the building of the system. The auditing process is the engine of further improvements to improve the effectiveness and the efficiency of the environmental management system.
- In a Cleaner production project the environmental review is done from or together with a consultant. In the case of an environmental management system the final certification is done by an external certifier, for EMAS by one that is accredited officially.

So, additional steps from a Cleaner production project for the introduction of an environmental management system are:

- involvement of all employees
- definition and description of responsibilities
- congruency of environmental planning process with management calendar and budgets
- definition and description of procedures
- clear, transparent documentation
- extension of areas under consideration (planning of plants, purchasing, products, communication, training, measuring equipment, abnormal situations, corrective measures, environmental records, audits)
- review of the system, not only the program

The Austrian Federal Secretariate for Science, Traffic and the Arts subsidized the introduction of environmental management system for 25 pilot companies in 1996 [12]. In the evaluation of this action, company represen-

Table 3

Matrix of the elements of a Cleaner production program and an environmental management system according to ISO 14001

ISO 14001	CP	Environmental Manager	Environmental team	Input/ Output and indicators	Material flow analysis	Energy analysis	Legal compliance audit	Environmental program (options and measures)
Environmental policy								P/F
Review of environmental effects				F	F	F		
Legal requirements							F	
Objectives and Targets Programme								P
Organization and responsibilities	P/F		P/F					P
Training								P
Communication			P					
Documentation				P	P	P	P	P
Procedures								P
Emergencies								P
Measurements				P	P	P		P
Correction and prevention			P					P
Records				P/F	P/F	P/F	P/F	P
Auditing								
Evaluation by top management								P

P = prepared by a CP (Cleaner production) project.

F = fulfilled (of course, this depends on the focus and the scope and the exact definition of the Cleaner production project, this table refers to CP as we understand it [2,4]).

tatives were interviewed for the project: this yielded surprising facts. On average, the project cost had a payback of 14 months. Additional benefit was seen in the reduction of risks, optimization of the organization and improved image. Minimization of risks means mainly the reduction of uncertainty regarding legal affairs, development of a controlling instrument and prevention of abnormal operation. Improved organization means the opportunity to document the companies' activities to provide environmental information.

In addition, a main focus is to detect weak points in the future more quickly and efficiently. In the course of the projects, in more than 40% of the companies technical innovation was stimulated (changes in materials, recovery of exhaust heat, introduction of water based paints). For more than 60% of the consultants eco-auditing is more stimulation of innovation than a control instrument. The study concludes that this was because most of the consultants who were active in the investigated projects had Cleaner production experience. The introduction of environmental management systems fosters the dissemination of specific know-how, the generation of this know-how however is attributed to Cleaner production activities.

Jürgens et al. [13] concluded from interviews with 13 companies which participated in the EMAS scheme of the European Community, that eco-audits can considerably contribute to improving environmental protection in companies by a better application of legal regulations and important improvements concerning the organization of environmental aspects as for the field of accident prevention. In addition to EMAS requirements, most

companies performed a flow analysis of their energy and material input and output. Most companies revealed, that the exact analysis of the material and energy flows entering and leaving the companies was a very important step during the work, which showed the amounts of waste and emissions, which were not previously known.

5. Advantages of introducing an environmental management system with a focus on Cleaner production

Basic elements of a successful environmental management system are:

- commitment of top management
- committed environmental policy
- clear aims
- a dedicated project manager
- an environmental team as a network covering all the organization and acting as multipliers
- immediate feedback
- increased room for action
- documentation of relevant data
- quick change
- information for everybody involved
- allocation of sufficient resources (time)

Analysis of the efficiency of the use of materials and energy leads to an increased efficiency of the whole enterprise. It yields a better use of materials and energy, and thus decreases the environmental impact and helps to decrease cost. It also gives a sound basis for an

environmental management system. Existing management tools should be integrated to avoid parallel developments.

Doing input/output analyses regularly yields an important information and controlling tool. EMAS and ISO 14001 are mainly focused on the auditing of the management system. So Cleaner production tools help the organization to understand and measure its waste, discharges and emissions. The standards and the regulation do not provide the organization with explicit tools to do so. Without a regular analysis of the flows of energy and materials caused by a company it has no real picture of its environmental relevance.

So we can go one step beyond a Cleaner production project towards a continuous improvement process to decrease the environmental effects of an organization by introducing an environmental management system based on Cleaner production. Cleaner production is focused on the improvement of the level of material and energy flows reaching partly into the organization's management system. Using it as a tool within environmental management guarantees, that the focus of the environmental management system really is on the important environmental effects. ISO 14001 does not specify the instruments used, Cleaner production can provide them.

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