

COMPARING POLLUTION PREVENTION PROJECTS IN ASIA AND EUROPE

The Set up, Implementation and Effectiveness of Pollution Prevention projects in the Netherlands and Thailand

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ABSTRACT

This paper introduces and compares pollution prevention projects in Thailand and the Netherlands. The institutional setting for pollution prevention is compared and some of the bottlenecks for further introduction of pollution prevention in both countries are analysed. Indications are given for strategies to further integrate pollution prevention in environmental policy and in activities of industries.

Key words: pollution prevention, pollution prevention projects, Thailand, The Netherlands

1. INTRODUCTION

Since the late eighties pollution prevention or waste minimisation has become a concept which is extensively used to influence the behaviour of companies in a more environmentally friendly direction. Pollution prevention projects have been carried out in various countries and with various designs. In this paper we compare the both the set up, implementation and outcomes of pollution prevention projects in the Netherlands and Thailand. We analyse the experiences with pollution prevention projects against the background of the specific institutional setting of these countries. Based on this, our aim is to give insight into the discretion needed when implementing policies in countries with such a diverse background against the backdrop of comparative studies showing how environmental policy innovations are spreading over the world with a rapid pace.

Our paper provides an overview of pollution prevention projects in both the Netherlands and Thailand. Both authors have extensive experience with projects in these countries. In the next section we provide data on the main actors in funding and designing pollution prevention projects and on the way pollution prevention projects are embedded in institutional structures, both for government and industry. Section 3 provides examples of

pollution prevention projects in Thailand and the Netherlands. Section 4 focuses on some of the main bottlenecks in the pollution prevention projects in Thailand and the Netherlands.

After providing these data for the respective countries we will compare outcomes and formulate various conclusions regarding the specificity of designing pollution prevention projects in these different settings in a final section.

2. OVERVIEW OF POLLUTION PREVENTION PROJECTS IN THE NETHERLANDS AND THAILAND

2.1 Pollution prevention projects in the Netherlands

The Netherlands initiated pollution prevention as part its environmental policy at the end of the eighties, and shifted the focus to preventive action at the onset of its first National Environmental Policy Plan of 1989. Prevention activities within companies have been stimulated throughout the last decade. First project efforts were started with the so-called PRISMA¹ at the beginning of the nineties. Provinces have played the main role in the implementation of pollution prevention projects. Most provinces in the Netherlands have set up a so-called 'prevention team' within their organisational structure. These teams initiate and co-ordinate pollution prevention projects and they often also provide the financial resources. The Ministry of Environmental Affairs sets out long term targets regarding the reduction of waste and emissions and the role of prevention in companies, and supports projects by providing some financial resources. Since the first National Environmental Policy Plan targets have been set for the reduction and re-use of waste and emissions, and various studies have indicated the prevention potential in several industries. Other organisations involved in pollution prevention projects include consultancy agencies or specialised research institutes (such as research teams based at a university) involved in the actual implementation of projects. They guide and assist companies in carrying out some of the tasks needed, such as the analysis of material flows. Also, intermediary organisations (e.g. trade associations) provide specific knowledge (such as knowledge on environmental problems and possible solutions for a certain sector of industry), assist in contacting companies and play a role in informing companies and others about the results of projects.

The first experiences with pollution prevention made use of the so-called Prisma-method. This method was developed on the basis of a Prevention Manual of the American Environmental Protection Agency (US EPA, 1989). It consists of four steps, (1) planning & organization, (2) assessment, (3) feasibility study, and (4) implementation. It essentially implies an comprehensive analysis of material flows that leads to the generation and implementation of a number of prevention options (Dieleman & de Hoo, 1993).

Most of the initial pollution prevention projects in the Netherlands made use of this method, sometimes in a slightly moderated form. The implementation of these project types requires active involvement of the participating companies as they play a significant role in the gathering of data, the analysis of material flows, and in the generation of prevention options. Thus, this pollution prevention method requires significant investments

¹ Dutch acronym for Project Industrial Successes with Waste Prevention.

from companies and project agencies in terms of time and money. For example, the first two stages of planning and organization and assessment typically took around 30 to 70 days from the company, and around 20 advisory days from the researcher, in the first original Prisma project (Dieleman & de Hoo, 1993: 251). In following projects based on these experiences time was managed more efficiently with an average of 20 days spent by companies for the whole project (information from the national projects, De Bruijn et.al. 1995: 78). At the start of pollution prevention government agencies and companies (mainly in the larger category) had the ability and willingness to make these investments. Later on, the call for more efficiency and the targeted introduction of pollution prevention in small and medium-sized companies (SME's), with less investment capacity associated to them, increased the need for cheaper and less time consuming pollution prevention methods. These new methods of pollution prevention are based on a more quick assessment of the opportunities for pollution prevention in companies and are less comprehensive than the original Prisma-method.

At the beginning of 2000 the Ministry of the Environment has set out a new implementation strategy for pollution prevention. Evaluations of the pollution prevention projects carried out in the Netherlands, estimated at more than a hundred in the past decade, show that while almost all branches of industry have been involved, there is still potential for prevention. Moreover, companies that are not interested are not sufficiently reached with the projects, and interaction with regulatory instruments can improve. The focus of pollution prevention will be broadened in order to generate more fundamental changes. The shift includes increasing focus to the design phase of products and processes and a shift from pollution prevention of individual companies towards companies in chains of production and consumption.

2.2 Pollution prevention projects in Thailand

Pollution prevention projects have been promoted in Thailand since 1990 with the support from USAID. During that period 38 factories were involved in the project. There were 3 demonstration projects (two textile factories and one pulp and paper factory). During the period of 1991-1994 Carl Duisberg Gessellschaft South East Asia Program Office (CDG-SEAPO) in collaboration with 3 Universities (Chiang Mai University, Asian Institute of Technology and Chulalongkorn University) performed a Waste Minimization Program for SMEs in 3 different industrial sectors, namely electroplating, textiles and tannery. In 1996, Federal of Thai Productivity Institute (FTPI) with financial support from Asian Productivity Organization (APO), performed a demonstration project on an electroplating factory. Since 1994, GTZ supports capacity building for the Department of Industrial Work (DIP) in promotion of Clean Technology in a number of industrial sector in Thailand. DANCED in collaboration with the Federation of Thai Industries (FTI) and the Thai Environmental Institute (TEI), performed a couple of Clean Technology demonstration projects during the period of 1996-1998. Since 1998, Thai Research Fund, has financially supported 3 Universities (Chiang Mai, Khon Kaen and Prince of Songkhla) in research projects on Cleaner Production in the Food and Agro-industrial Sector.

Actors involved in pollution prevention projects

Since 1990, there were quite a number of donors from developed countries, promoting the concept of pollution prevention program in Thailand. Each donor normally contacted with their networks in obtaining local counterparts. At present there are quite a few

organizations in Thailand involving in Pollution Prevention activities. Normally they could be categorized into 3 parts. The first one is the group of academics in different parts of Thailand. Most major universities in Thailand will normally form groups in working with the project. At present there are Pollution Prevention groups in Chiang Mai University, Khon Kaen University, Prince of Songkhla University, Kasetsart University, Chulalongkorn University, Mahidol University, King Mongkut Institute of Technology and Asian Institute of Technology. The second group is of government authorities involved in environmental control. There are teams in the Department of Industrial Works, the Department of Industrial Promotion, from the Ministry of Industry and a team from the Pollution Control Department, Ministry of Science, Technology and Environment. These groups play roles in both assisting industry in Pollution Prevention projects and in environmental control issues. The third category is NGO or private initiative. There are quite a few organizations establishing Pollution Prevention units in their organisation to assist their member or public in this field. The Federation of Thai Industries established a Clean Technology Center in their organization. Thai Environmental Institute and the Federation of Thai Productivity Institute also created a group of CT in their office. These groups work normally as consultants for individual industry or sometimes work for donor agencies in the related field.

2.3 Summary

Early efforts in pollution prevention originate in both countries from the beginning of the nineties. In the Netherlands pollution prevention has gained a specific position in environmental policy and has been developed as a tool to reach overall targets set for reduction of waste and emissions. In terms of organisation, provinces have played an important role in initiating various projects, and funding has taken place both at the national and provincial level. Thus pollution prevention has become embedded in environmental policy, and recent efforts are aimed at giving pollution prevention a place in regulatory efforts, for example by obliging laggard companies to carry out a pollution prevention analysis. In Thailand pollution prevention is much less integrated in environmental policy, and has much more been driven by external donors. The number of pollution prevention projects in Thailand is limited compared to the Netherlands, and while in the Netherlands studies indicate that most companies have been to some extent involved in pollution prevention, most companies in Thailand have not carried out pollution prevention activities. Networks of actors involved in pollution prevention have become quite extensive in the Netherlands, and have extended from the individual projects to consultancies that have incorporated cleaner production as a specific commercial focus in their activities. In Thailand main activities regarding pollution prevention center around various academic research groups in connection with donor agencies. Pollution prevention has gained less footing in engineering and consultancy firms and pollution prevention exercises play only a limited role as a commercial service.

The next section gives some more detailed information on pollution prevention activities in Thailand and the Netherlands.

3. EXAMPLES OF POLLUTION PREVENTING PROJECTS

3.1 Waste Minimization Program of Cannery and Fruit/Vegetables Preservation

Factories in Northern Thailand.

The food and agro-industry is one of the key manufacturing sectors in Thailand, generating exports worth approximately 201-293 billion bahts (5.1-7.5 billion US\$) during the period of 1993-1999 or equivalent to 18% of Thailand's total export value. Overall, the government considers sustained growth of the food processing sector a highly important component of its national strategy for emerging from the economic crisis due to the sector's heavy usage of local materials and its high labor intensity.

Chiang Mai University (CMU) in collaboration with The Northern Industrial Promotion Center and The Provincial Industrial office, with financial supports from the Thai Research Fund (TRF) performs Waste Minimization studies in 12 food industries in the northern part of Thailand. Six factories are from the cannery sector and they produce fruit salad, pineapple, palm seed, young corn, corn, and tomato in cans. Another six factories are from the food preservation sector. They produce prickle ginger, vegetable and fruits (mango, plum, etc.). The selected factories are small and medium scale factories. The main objective of this project is to perform the waste minimization program on cannery and preserved fruit & vegetable factories in northern Thailand. The specific objectives are as follows:

- To obtain benchmarks of waste minimization program of this industry sector in northern Thailand.
- To obtain demonstration factories for waste minimization program in cannery factories and preserved fruit & vegetable factories.
- To obtain information on the Environmental Management System of the factories.

The methodology of the project is as follows:

- Performing a document survey on the chosen industry sector in northern Thailand (17 provinces)
- Two workshops on waste minimization program were performed for two sectors (cannery and fruit and vegetable preservation factories). This will give some knowledge on waste minimization program to the enterprises and to request 6 volunteer cannery factories and 6 volunteer fruit & vegetable preservation factories to join the waste minimization program.
- The volunteer factories were chosen according to their willingness of top management and according to sizes (2 small, 2 medium and 2 large scale factories.)
- Waste Minimization programs were conducted in each selected factories.
- The results obtained from conducting the program were evaluated.

Outcomes of the project

Most of the participating factories are small and medium scale industries. Their investments were in the range of 5-180 million Baht. The canning factories produce all kinds of canned fruit such as pineapple, corn, fruit-salad, palm seed, lychee, etc. The fruit and vegetable preservation factories produce salted ginger, salted vegetables, and salted fruit etc. Most medium scale factories export their products. The capacities of the factories are in the range of 1-150 tons per day. They had never done any activities concerning

pollution prevention practices before. The results presented in this paper come from 6 cannery factories involved in the project.

Technical outcomes from the waste minimization program.

Wastewater and solid waste, generated in the selected factories, were as shown in Table 1. Wastewater generated from canneries could range from 9-238 m³/day, depending on size and capacity of the factory. To be able to compare the water used, waste generated per ton of raw material is calculated. The amount of wastewater generated was in the range of 1-5.29 m³/ton raw material. Wastewater treatment facilities used by the factories are land treatment, aerated lagoon, anaerobic filter and activated sludge process. Solid wastes generated from factories are mainly peels of raw materials and cut (left over) of waste products. They are in the range of a few kilograms to many tons per day. Solid waste could be in the range of 0.3%-72% of raw materials, depending on what kinds of raw materials are used in the process. For example, pineapple and corn generated about 65-72% solid waste from raw materials. Other products could produce 0.3-10% solid waste from raw materials. Most waste can be use as food for animal feeding such as corn and pineapple waste. Some may be used for compost.

Table 1 Waste Management in the Selected Factories

	Wastewater			Solid Waste			Raw material (Ton)	
	Amount		Treatment method	Kind	Amount			Treatment Method
	(m ³ /d)	(m ³ /Ton) RM			(kg)	(kg/Ton) RM		
Canning Factories								
No.1	8.93	4.72	AL	fruit & peel of fruit leftover	77.2	40.8	Food for Animals & Fertilization	1.89
No.2	86	4.35	LT		243	12.3	LF offsite	19.77
No.3	89	4.45	AL	peel & cob of corn and corn leftover	14,528	726.4	Food for Animals	20
No.4	82	3.73	AL	lychee leftover	62.4	2.84	LF offsite	22
No.5	134	1	AL	pineapple peel leftover	87,330	656.6	Food for Animals	133
No.6	238	5.29	AF+AS	peel & cob of corn and corn leftover	33,000	569	Food for Animals	45

Remark : AL = Aerated Lagoon, AF = Anaerobic Filter, AS = Activated sludge Process, LT = Land Treatment, LF = Land Fill

After the information collection and analysis of data, problems were identified and proposed options were determined as shown in Table 2. There are 4 important categories concerning problems in the factories. The first one and very important part is good house keeping. Most factories used too much water in their production activities. Water hoses were too big and without valves in stopping water flow when water was not needed. Pressurized floor washing tools were not available. Leakage could be seen everywhere and there was no waste segregation system in the factories. The second important problem is process modification. In many cannery factories chemicals have been used extensively in the production process. For example in longan and lychee canning, a lot of calcium chloride and citric acid have been highly used for hardening of products. A lot of syrup has

been leaking and it will introduce high BOD content in their wastewater. The third category is energy use. Many factories turn on the lights in the production area even during the day time. This is due to the fact that there was no energy saving consciousness during the factory design stage. Transparent roof tiles could save a lot of energy. Most food factory processes will need boiling or heating of their materials prior to canning. Factories discharged a lot of high temperature wastewater down the drain. They should provide energy recycle facilities to trap this waste. The final and most important factor affecting the performance of the management system in the factories is human resources. Training or further education should be provided to the factory staff on a regularly basis.

Table 2. Problems identified

1. Good Housekeeping Practices
1.1 No recycle facility for cooling water
1.2 No recycle machine for can washing process
1.3 Too big water hose for floor cleaning
1.4 No valve at the end of water hose
1.5 No jet floor cleaning
1.6 Pipe leakage
2. Process Modification
2.1 Use too much chemical substance for soaking process
2.2 Spillage of syrup
3. Energy
3.1 Use too much energy in lighting
3.2 Hot wastewater discharge directly into sewage drain
4. Human Resources
4.1 Worker s had no awareness on good house keeping

By using good housekeeping practices deriving from pollution prevention activities, wastewater generated from many sources could be reduced. Table 3 shows amounts of wastewater generated per ton raw materials of many processes in the factories. In the case of a lychee factory, chemical wastewater generated from soaking was reduced from 1.38m³/ton raw materials to 0.96 m³/ton raw materials (RM). Washing wastewater was reduced from 5.55 m³/ton RM to 3.10 m³/ton RM. Proper maintenance of the can washing machine could reduce wastewater from 0.38 m³/ton RM to 0.20 m³/ton RM. In terms of money the factory could save about US\$ 7,392 per season. In the case of the selected pineapple factories, options in solving generation of wastewater were to change rinsing system on conveyor belt into soaking system. Overall wastewater generated was reduced from 2.45 m³/ton raw materials to 1.01 m³/ton raw materials. In the case of a palm seed factory, wastewater was reduced from 6.29 m³/ton raw materials to 4.35 m³/ton raw materials, by changing the washing process and using good house keeping practices.

Table 3 Wastewater Reduction through waste minimisation measures

Factory	Before Implementation waste / unit RM. (m ³ /ton)	After Implementation waste / unit RM. (m ³ /ton)
1. Lychee factory		
• Saving chemical through Soaking process	1.38	0.96
• Changing washing process	5.55	3.10
• Maintenance of washing Machinery	0.38	0.20
2. Pineapple factory		
• Change whole process	2.45	1.01
3. Palm seed factory		
• Adding valve at the end of hose in soaking process	0.79	0.38
• Good house hold keeping Workers in washing process	2.54	2.02

3.2 Two examples of Dutch companies involved in pollution prevention projects

This section provides experiences of two companies in Dutch pollution prevention projects, for more detailed information on pollution prevention projects in the Netherlands see de Bruijn and Hofman (2000). The first case is an example of a company involved in a pollution prevention project based on the Prisma methodology. The second company was involved in a so-called quickscan project in which in a very short time-span and based on previously formatted prevention forms the company is scanned for prevention potential.

The first case company produces different styles of furniture for the mass market and participated in a pollution prevention project in 1993. The company is a SME with 45 employees, and has appointed a co-ordinator of quality and environmental issues. The company invested 25 days in the project. The project generated roughly 35 options for the company, of which eventually almost 25 measures were implemented in the company. Some examples are:

- ordering of exact sizes of raw material (mostly wooden barks and plates) leading to less waste;
- improved planning of work, resulting in a decreased loss of material. The planning has been fully computerised;
- the instalment of new welding technologies, resulting in less waste material;
- the use of return packages, leading to a decreased use of raw materials;
- the installing of a new paint process, with an optimisation of the paint cabin including the instalment of a distillation process.

The project resulted in positive financial and environmental effects although a company respondent could not give exact figures. After the project was concluded, the company has continued to work on pollution prevention. It periodically investigates its material flows and has developed some options.

A second example of a company involved in pollution prevention is provided by another furniture manufacturer, also a SME, which participated in a so-called quickscan pollution prevention project in which it invested one day. The quickscan resulted in five related options that were all realised. It concerns the separation of waste from one to five waste

flows. Three flows are now being reused externally (two wood flows, one paper flow). The company is satisfied with the project. Its knowledge of waste flows has been improved and thanks to the project the company could clear some problems with the legal authorities. After the project the company has not generated any new options. For them it was a positive one-time experience. The concept of pollution prevention plays no further role in the company.

4. BOTTLENECKS IN POLLUTION PREVENTION PROJECTS IN THAILAND AND THE NETHERLANDS

4.1 Thailand

Even though the result of pollution prevention projects seem to be very promising, there are quite a few bottlenecks in setting up and implementing the programs, especially for SMEs. The bottlenecks which could be identified through our projects are:

a) The multiplying effect seems to be very slow considering the amount of effort of many organisations that have invested during the last decade. There are quite a few programs working in Thailand during the last ten years. Most previous programs were supported from many donors from developed countries and international organisations. They were heavily subsidised both in consulting and hardware support in implementing pollution prevention options generated from the project. Certainly, this will lead to be a very good demonstration project of which can be used as an example for other factories. This naïve way of thinking seems not to work well in developing countries. It seems that most factories agree that the programs are useful and could save a lot of money, but they are waiting for the next supporting project so that they can apply for subsidy from the donor agencies.

b) Later, there were quite a few programs implemented and supported by local organisations. These programs were subsidised mainly on consulting fees in implementing pollution prevention in the factories. The outcome of the project depends a lot on the willingness of the factories involved. Since they have to pay every thing themselves in implementing the generated options from the program, they will need to take their priority in the company for consideration. The immediate implementation of PP options are rare especially with those involving in a significant sum of investment. Those options will be delayed to a later state. The willingness of top management is a crucial issue in implementing PP program in this category.

c) Even though the top management is willing to work on the program as he/she realised the benefit in implementing the selected options. The economic situation does not allow them to act promptly, due to the cash flow problem. The company finds it is difficult to invest in something which is neither forced by regulations nor customers' needs and the result is that all options will be put as a low priority in the factory.

d) Most of the programs involved rather high consulting fees as the program itself involves many experts and time for implementation. With limited amount of financial support, and human resources the multiplying effect of pollution prevention program are quite low.

4.2 The Netherlands

Pollution prevention has proven to be a valuable concept in the Netherlands, because of its prime focus on material flows (where the causes for environmental problems can be found) and the emphasis on minimisation of environmental effects. Most pollution prevention projects have succeeded in realising improvements in efficiency and reductions in waste and emissions for the participating companies. Pollution prevention does however not necessarily lead to profound changes or improvements in production processes. More comprehensive types of pollution prevention projects have however resulted in fundamental innovations. Another aspect, in which pollution prevention projects have proven its value, has been in involving companies. Through the set up of project teams for pollution prevention in companies and the organisation of brainstorm sessions with employees to generate ideas, pollution prevention projects have the potential to bring about change in the participating companies. This is the type of change in the management and organisation that can lead to the incorporation of the method of pollution prevention in a companies' strategy. However, pollution prevention projects in the Netherlands have developed towards less comprehensive pollution prevention projects that are less likely to initiate these types of changes.

Secondly, pollution prevention projects often only lead to a limited kind of grounding of the continuous process of pollution prevention. For a lot of companies the pollution prevention project is a one time experience directed to the generation and implementation of options, but only limited learning effects have been created with regard to the concept of pollution prevention as the example of the second company in the previous section shows. Therefore, not much has changed in most companies with regard to environmental management and organisation. Companies may stay busy with the development and implementation of new options, but this does not imply changes within the organisation. It is a limited process of change and not the start of an on-going learning process.

An important aspect for pollution prevention projects relates to the kind of companies that participate in pollution prevention projects. It appears that participating companies in pollution prevention projects in the Netherlands are certainly not among stragglers with regard to environmental issues, and in some cases they are front-runners regarding environmental issues in their specific branches. It proves to be difficult to engage those companies (stragglers) where the potential for pollution prevention might be the highest.

The main problem that can be identified exists in the continuation of pollution prevention after a project (initiated from outside the company) ends. Research indicates that in order to move beyond the one time impact of a pollution prevention project, and for companies to use pollution prevention as a concept for environmental management and organisation, it is necessary for companies to go through a learning process. Most projects, especially those using quickscans, do not sufficiently initiate this learning process.

5. Comparing pollution prevention in the Netherlands and Thailand

In the Netherlands the low hanging fruit has been picked with regard to pollution prevention (easy options have been implemented and active companies have participated), and pollution prevention projects now need to develop to a new stage. Main challenges are to reach and engage laggard companies, and to realise more fundamental changes in production processes.

In Thailand there is still much scope for picking the low hanging fruits as most companies have not yet participated in pollution prevention projects and have a very limited focus on opportunities to reduce raw material use and waste stream production. There is potential for pollution prevention in companies, also in SMEs as is shown in the presented pollution prevention project.

Institutionally, on the one hand pollution prevention has gained commercial footing through consultancy firms in the Netherlands, while on the other hand government policies continuously pressure companies to become involved in pollution prevention. Companies themselves and intermediaries such as branch associations increasingly acknowledge the benefits of pollution prevention, both in environmental as well as in economic terms. Active companies often already have incorporated pollution prevention into their management. In order to reach laggard companies prevention activities are introduced in the regulatory permitting system, obliging companies to take preventive action. In Thailand networks have been formed mainly through funding of donor agencies, with involvement of academic institutions and government agencies, while pollution prevention has only limited footing in engineering and consultancy firms and companies at large. In order to overcome some of the bottlenecks, a more coherent strategy for promoting pollution prevention in Thailand could be developed, also to some extent based on the lessons learned in other countries, such as the Netherlands. One aim should be to strengthen the capacities of consulting agencies throughout Thailand. Also pollution prevention methodology should be simplified in such a way that they become more cost-effective. Factories should be able to implement pollution prevention by their own with the help of for example one consultant, and not a whole team. If technical problems occur, they should try to seek the help from professional agencies in the country. To be able to obtain these consultants a series of training program for the trainers should be prepared.

Financial support would be required for these training programmes and follow up support for these consultants in order to work closely with factories. Setting out a strategy for the longer term with the involvement of government agencies, associations, and professional agencies could still benefit from help through external assistance, but can make the process of capacity building less dependent of the individual contributions and agendas of donor agencies. While strategies in the Netherlands need to be focussed on reaching laggard companies and generating more fundamental change, strategies in Thailand should increase the on developing a more comprehensive network of actors involved in pollution prevention, in order to transfer the message of the potential of pollution prevention to the bulk of companies.

REFERENCES

- Bruijn, T.J.N.M. de, and P.S. Hofman, Pollution Prevention and Industrial Transformation, Evoking Structural Changes in Companies, *Journal of Cleaner Production*, Vol. 8, No. 3, pp 215-223, 2000.
- Dieleman, H. & S. de Hoo, Toward a Tailor-made Process of Pollution Prevention and Cleaner Production: Results and Implications of the PRISMA Project, in: K. Fischer & J. Schot (eds.), *Environmental Strategies for Industry*, Washington DC, 1993.
- US EPA, *Waste Minimization Opportunity Assessment Manual*, 1989.