

Working Report No. 5 2002  
Arbejdsrapport fra Miljøstyrelsen

## Cleaner Technology Projects in Denmark 1996

Summaries of all Project Reports and Working Reports  
on cleaner technology published by the Danish  
Environmental Protection Agency in 1996

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**Danish Environmental Protection Agency**

Danish Ministry of the Environment

This report is subsidized by the Council for Recycling and Cleaner Technology.

Please note that the contents of the report do not necessarily reflect the views of the Council or the Danish Environmental Protection Agency.

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# Preface

This Working Report contains summaries of all Project Reports (*Miljøprojekter*) and Working Reports (*Arbejdsrapporter*) on cleaner technology published by the Danish Environmental Protection Agency (EPA) in 1996.

The projects were carried out under the Danish Environmental Protection Agency's Action Plan for Cleaner Technology 1993-97, the main objective of which is to ensure the implementation of results from previous Action Plans, to continue research and development activities, e.g. substitution of environmentally harmful substances and materials, and to shift focus from production *processes* to *products*.

Conscious efforts to minimise environmental impacts are becoming competitive parameters for the industry. The implementation of cleaner technology has proven to entail savings in operation costs and lower costs of production, and these results are communicated through the project reports.

Cross-references are given to projects that form part of major programmes, or where previous or subsequent projects deal with the same topic.

Since the Working Reports are only published in limited edition, some reports may not be available. However, the reports can be found at the Danish Environmental Protection Agency's homepage [www.mst.dk](http://www.mst.dk) in PDF format. Moreover, the Working Reports can be borrowed from EPA's library.

The Environmental Projects are sold through EPA or *Miljøbutikken*, or they can be borrowed from public libraries.

In each summary is given the name of the author(s) and the project institution(s) for further reference. It should be noted, though, that the authors may have changed position since then.

This summary report is also available in Danish.

# Review of Cleaner Technology in the Fish Processing Industry

## Oversigt over renere teknologi i fiskebranchen

### Miljørapport nr. 317, 1996, Miljøstyrelsen

**The Danish Environmental Protection Agency has decided to make an appraisal of completed technology projects concerning the development of cleaner technology in the fish processing industry. This report presents a collection and a review of the gained results. The review covers a list of how to improve the environment and an account of the economic consequences of implementing cleaner technology. The environmental improvement, together with the sound economy in the investments, has already contributed to spreading the use of the project results in the fish processing industry.**

The reviewed technology projects are completed in the herring filleting industry, the tinned herring industry, the beluga industry and the shrimp industry.

The primary target group is expected to include the herring industry, the mackerel industry, the beluga industry and the shrimp industry together with the engineering firms who work with local authority wastewater-treatment plants and the administrative authorities. The secondary target group consists of fishmeal factories and the food industry in general.

The first section presents the preliminary investigation from 1988 into the possibilities of implementing cleaner technology in the fish-processing industry. The following sections treat the more specific experiments with cleaner technology in the single fish processing industries.

Subsequently, the results of the preliminary investigation from 1988 are presented. The investigation includes a statement of the water consumption, the concentration of wastewater and a number of proposals on how to purify wastewater.

Further, the environmental project number 97 "Cleaner Technology in the Fish Processing Industry" is presented. The project is a fact-finding mission, which was carried out in the period between 1987-88. The project deals with 9 representative firms from the herring industry and the beluga industry. The water consumption and the environmental impacts of the different stages of the firms' production are analysed.

The information system for cleaner technology (Rentek) is presented. The filleting of herrings, whether the final product is a fresh or frozen fillet, is given as an example.

Projects completed in the fish processing industry are presented. The aims of these projects were to develop practical and economic methods for reducing the water consumption, the level of pollution of the wastewater, and to increase the sales value of waste products.

In a separate section, projects completed in the tinned herring industry are presented. The aims of these projects were to develop practical and economic methods for reducing the water consumption and the level of pollution of wastewater.

There do not exist any projects on cleaner technology in the beluga industry. In stead, it is estimated what effects can be expected on the water consumption and the emission quantities if the industry learns from the experience and technologies of similar actions of the herring industry.

In the shrimp industry the aim of the projects was to find a practical and economic method for reducing the water consumption and the level of pollution of wastewater. Another aim was to find alternative market possibilities for the by-products from the production.

Finally, the project “Cleaner Technology in Cleaning” (Renere teknologi ved rengøring) is presented. The aim is to investigate the possibilities of introducing cleaner cleaning technology in the roundfish industry and the flatfish industry. In this section, a project, which looks into the possibilities of purifying the herring industry’s wastewater to a degree, which ensures that the wastewater can be recycled, is presented.

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This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0105-3094

ISBN no. 87-7810-538-3

# Guidelines for the Development of Sustainable Electronic Products

## Retningslinier for udvikling af bæredygtig elektronik Miljørapport nr. 319, 1996, Miljøstyrelsen

**In the past years environment, work environment and use of resources have been paid increasing attention. This fact has resulted in increasing demands for products that cause minimum effects on the environment throughout their life cycle and aim at a sustainable production. Therefore, it is considered relevant to give firms the possibility to chose environmentally friendly alternatives and thereby encourage them to move towards more environmentally friendly products. This report is a guide to firms to stimulate a production of electronic products, which is both economically sustainable and causes less damage to the environment.**

Production will always affect the external environment and the work environment and draw on the resources to a varying extent. The effects depend on:

- The composition of the product
- The materials used for the product
- The processes of the production
- The transportation and use of the product
- The disposal of the product

These parameters can normally be influenced to the benefit of the environment, if the firms, when developing their products, are aware of the existing possibilities and at the same time pursue an environmentally friendly policy.

Especially regarding the electronics industry, which manufactures very complex products, it is a far-reaching assignment to describe effects on the environment. Therefore, many electronics businesses find it difficult to incorporate the environmental parameters in their product development. This guide was developed to help these businesses. The guide contains two types of information:

- A short introduction to environmental issues and environmental concepts. Concepts and terminology concern the external environment, the work environment and use of resources.
- Environmental guidelines for materials, electronic components and processes for production of electronic products.

One chapter in the report is dedicated to the evaluation of the environment. The chapter gives a brief presentation of the procedure to follow when evaluating the environment and offers tools to an environmental evaluation of the products. Following issues are examined:

- Awareness of the environment in the process of product development including Life Cycle Assessment.
- Insufficient technical data and guidelines
- The life cycle of a product
- Evaluation of the environment



- The Danish UMIP method, which is based on SETAC (Society of Environmental Toxicology and Chemistry) principles.

The procedure is illustrated through two examples.

One section treats the conventional materials and processes. The section illustrates the life cycle of typical electronics products with a view to composition of materials and production processes. The guidelines are information about the environmental consequences that are typically connected to the choices regarding the manufacturing of products, materials and processes. The guidelines are based on knowledge of environmental issues and on experience drawn from earlier environmental evaluations. They give information about what is considered appropriate environmental practise. The guidelines are structured in a way that they follow the typical process of choices in the development of electronics products.

The Guidelines consists of a number of data sheets and are classified in different fields of study. They describe random electronic equipment and give information about the following three levels:

- A general description of environmental concepts and environmental consequences in connection with the production and disposal of electronic equipment.
- A detailed description of the main components in electronic equipment.
- A detailed description of different types of components and materials.

The guidelines contain an extensive appendix of data sheets and a table of contents to present an overview of these.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0105-3094

ISBN no. 87-7810-574-9

# Impact of Regulation on the Development of Biotechnology

## Impact of Regulation on the Development of Biotechnology Miljørapport nr. 322, 1996, Miljøstyrelsen

**Growing concern with the adverse effects on human health and the environment from the use of chemical crop protection agents has brought about a tightening of the demands for product authorisation and risk assessments in Denmark and the EU in recent years. At the same time Denmark has issued bans on the use of certain substances and products, while taxes have been imposed on other products on the market. Between them the three initiatives are intended to contribute towards a reduction of the consumption of chemical agents while at the same time such consumption as does take place involves no unnecessary risk to people and the environment.**

Chemical products are thus facing a serious impairment of their position in the marketplace. Bans and taxes have a particularly adverse impact on the market whereas, on the other hand, enhanced authorisation demands do not seem to have any crucial influence in the light of the agro-chemical enterprises' total costs of developing a new crop protection agent.

In parallel with this, demands have been introduced for product authorisation and risk assessment of microbiological crop protection agents. This renders enterprises within this area liable to costs that weaken the products' possibilities on the market in the short term. The reason is that the costs of risk assessment are relatively high for these products in view of the comparatively narrow market that the products typically address.

At first glance, the introduction of this weakening may seem paradoxical - bearing in mind that microbiological agents are generally regarded as environmentally favourable. In the longer term, however, there may be prospects of a professionalisation of the market resulting in enhanced recognition of the products.

Exemption from taxes, subsidies for research, and the introduction of rules of priority for the authorisation of products may, added together, promote the development and increase the business community's incentives within the area.

In the field of plant breeding the development of transgenic plants represents a new option. One may fear that the introduction of risk assessments and authorisation requirements will hamper the development in the area, but Danish experience does not seem to support this. The costs of risk assessment are not on such a scale as to have any influence compared with the overall costs of developing a transgenic plant.

Overall, the market for chemical crop protection agents is being curtailed. The market for microbiological agents will be weakened in the short term but strengthened in the longer term by virtue of the weakening of the position of the chemical products as well as by virtue of various stimulative policy initiatives. The development of transgenic plants is not hampered by regulation and favourable possibilities are predicted for them - notably in the light of the difficulties faced by the chemical agents.

The impact of regulation on the possibilities of biotechnological products is generally favourable by virtue of the stimulative initiatives for the biotechnological products and restraining measures for the competing chemical products.

The crucial factor for the development in biotechnological applications within the field of crop protection is not environmental regulation or risk assessments. It is the regulation in terms of ongoing agricultural policy, first and foremost, under the auspices of the common agricultural policy in the EU, and the interaction this policy has with the market. The impact of this on the choice of crop, pest protection strategy, and technology and product development in the field of crop protection is significantly greater than the environmental regulation.

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This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 87-7810-571-4

ISBN no. 0105-3094

# Integration of Cleaner Technology in Environmental Case Work

## Integration af renere teknologi i miljøsagsbehandling

### Miljørapport nr. 331, 1996, Miljøstyrelsen

**In 1992 environmental protection was introduced into Danish law. In the wake of the renewed environmental legislation followed a number of questions, among other things, because a regulation through cleaner technology interferes in the internal affairs of a company. The present project aims at mapping out the companies' and the authorities' attitudes to cleaner technology in the environmental casework and at describing methods to the improvement of the interaction between the parties.**

The report contains a description of the applied method (chapter 2), a review of cleaner technology in relation to environmental legislation (chapter 3), the result of a round of interviews (chapter 4), a round table discussion (chapter 5), a description of the final conference (chapter 6) and a summary of conclusions and ideas (chapter 7).

The results of the project can be summarised as follows:

- Even though cleaner technology legally had to be included in the case administration of environmental approvals since 1992, there is still a lack of good examples. It is assumed that the authorities and the companies do not have significant knowledge on cleaner technology and that this is caused by a lack of experience in the field.
- It is generally agreed that the legislation constitutes a good frame for the authorities' guiding role, and that implementation of cleaner technology should be voluntarily, since successful work with cleaner technology depends on the company's own dedication to the work.
- Cleaner technology is not only a question of technical solutions, but also about strategies, attitudes and organisation of the environmental work. Authorities and companies should be aware of this fact.
- In fact, the legal system only empowers the authority to require cleaner technology in a company's own production process. However, through dialogue the authorities can also focus on the areas, which relate to the whole life cycle of the product, e.g. the manufacturing of raw materials, the employment phase and the disposal of the product.
- The companies' formulation of an application for environmental approval is in itself a good practice, which can prove to have a motivating effect and give the companies an insight into their own environmental situation. The authorities should attach importance to entering into dialogue with the companies in this phase, as it is the best time to motivate the companies to implement cleaner technology solutions.
- The authorities' expectations to the companies' change of productive equipment should be brought in line with the company's actual plans for replacement. In this connection, the formulation of plans of action for the company's implementation of cleaner technology can be an appropriate tool.

- Considering the fact that companies are different, there is a need for the authorities to adjust their authority role according to the situation. The guiding and motivating role is suitable towards the companies who have a positive attitude towards the environment and towards the group of companies who can be motivated to adapt a similar attitude. It is only appropriate to exercise control over the companies who are least motivated. It is generally agreed that the authorities should only realise investigative activities in the latter group of companies.
- It is important that every single authority makes a decision on where to act and on how to set priorities for the resources in relation to the different groups of companies.
- The decentralised authorities can promote the implementation of cleaner technology by playing a more pro-active role in the guiding of the companies. In this connection, the authorities could arrange information meetings, establish groups for interchange of experience, establish networks, etc.
- Trade associations can play an active part in the promotion of cleaner technology by guiding and inspiring companies and by entering into voluntary agreements with the centralised authorities.
- In general, both the companies and the authorities have a need for a greater knowledge on cleaner technology. This can be gained through more effective information about the results of the finished projects. Moreover, there is a need for preparing the authorities' environment workers for a better co-operation with companies in order to make it easier to keep a process going.

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This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-3094  
ISBN no. 87-7810-617-6

# An Evaluation of the Project "The Contractor's Environmental Guide"

## **Erfaringer fra formidlingsprojektet "Entreprenørens Miljøguide" Miljørapport nr. 333, 1996, Miljøstyrelsen**

**This report evaluates the project "The Contractor's Environmental Guide". It includes the most important experiences gained during the course of the project. The intention is that others working on similar communication projects should be inspired by this work and, to a certain extent, be enabled to make use of the gathered experiences.**

In the years to come the building and construction industry, as well as many other industries, are sure to be met with an increasing amount of environmental management demands. Contractors can essentially influence the environment from tendering and contract negotiations up to the day that the completed project is handed over. When a construction firm engages in environmental management, it basically prepares itself to meet these demands, since environmental management is a systematic and preventive attitude towards managing environmental matters.

The Contractor's Environmental Guide is an information material, which deals with environmental management in contracting firms. The material is specifically designed for those contracting firms that may have a desire to work seriously with environmental management. It provides instructions for active work in the firm and can be used as a tool, when initiating the environmental management process.

In some aspects the project was very untraditional: First of all, the users have been included in the process from the beginning of the project. Second of all, there has been a focus on the guide's adaptation of the industry's knowledge and attitude barriers. Finally, the special collaboration between the researchers and contractors is reflected in the principles and methods recommended in the guide. Because of the characteristics, it has been possible to get one step further with the analysis of problems and solutions.

Thus, knowledge transmitted in the manner that the guide utilises becomes more present, interesting and motivating. An information material of this character, where information and knowledge is separated, differentiated and distributed through transmission, will therefore be a powerful tool when an organisation engages in knowledge and attitude building. This effect can be credited to the materials concerned with the specific problems and possibilities of the target groups – and also because it is done with insight in the attitude, knowledge, culture and language of the target group.

The Contractor's Environmental Guide project resulted in the publication of the information material by the Danish Contractors' Association, as well as the Danish Environmental Protection Agency's publication of a preproject and the present evaluation report.

The information material consists of 4 booklets about environmental management aimed at the different organisational levels in the contracting firm, 2 publications as technical support for the booklets, a video with the title "Entreprenøren og Miljøledelse" (The Contractor and Environmental Management) and an information pamphlet which provides an overview of the Contractor's Environmental Guide, as well as an order form.

The most important experiences from the process of developing the information material are:

- On the one hand involvement of the users is extremely time and resource demanding. On the other hand, the users' active participation in the process contributes highly to secure the quality and utility of the material for practitioners, just as it initiates a debate in the industry and thus raises the interest for the project and the common knowledge of its existence.
- The combination of the analyses of the target group and the mapping of the need for knowledge with the involvement of users are a powerful tool in limiting and defining the scope of information.
- It was important to be cautious when the information was distributed and communicated to each target group and each function.
- The technical communication part of the process was very time demanding. It required resources and time for linguistic and layout design for a good result. This provided a lot of possibilities for good effects and highlighted important messages.

The implementation of the guide as a tool in the industry was a great success factor. It was important to advertise the existence of the material and the concept before, during and after the publication of the guide. This promoted the project to users, researchers and other interested parties and also elicited feedback and discussion.

Although the Contractor's Environmental Guide is finished, the work is not yet done. The project initiated a process, which should be followed up and developed further. It is necessary to keep on working and co-operating in the whole building and construction industry, if the industry is going to achieve a more sustainable development.

Many people have helped in order to get the project going and see it carried out. These people have improved the project, but have also required extra administration. Many of these helpful people are "fiery souls", who are idealistic and interested in the field. Although we have not always agreed 100% with them, there is no doubt that the project would never have reached the present level without their participation.

This project has demonstrated that it is possible, within relatively limited time span and limited resources, to produce an information material that covers a specific need for knowledge about the environment and environmental management.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0105-3094  
ISBN no. 87-7810-643-5

# Environmentally Sound Stoves and Ovens

## Miljøvenlige komfurer og ovne

### Miljørapport nr. 338, 1996, Miljøstyrelsen

**The report examines the life cycle of a stove and analyses and evaluates the most important health- and environmental issues. Several choices of technology have been tested but the report cannot point out one of them as being the best solution. The conclusion is that the future development should be concentrated on the energy consumption when using stoves and ovens since this is the main problem when it comes to environmental strain.**

More than 150.000 Danish families buy a new stove every year. At the same time the old stove must be disposed of, and this generates about 7.500 tonnes of waste of which most is recycled. The greatest environmental impacts come from the use of the stoves as the average Danish family annually consumes 400-600 kWh for cooking. The consumption of energy is based on fossil fuels, and the conversion causes a significant contribution to global, regional and local health and environmental impacts.

The report analyses different technologies for cooking. The conclusions are expressed as advice to product developers, producers and consumers on how to reduce the overall impact on health and environment. The methodology used is based on the life cycle concept, i.e. that all major impacts from acquisition of raw materials to final disposal have been taken into account. It should be stressed that many of the results and conclusions apply only to Danish conditions as these have been the basis for most of the analysis.

The target group for the investigation is product developers, stove manufacturers and public and private consumers. Together, these actors are responsible for the overall impacts throughout the lifetime of the stove.

The impacts from a stove were analysed considering the following elements: Consumption of raw materials, consumption of energy, environmental impacts (global, regional and local), health and risk of accidents.

The analysis of the raw material consumption show that the essential materials (iron, steel and other metals) generally stays in circulation (i.e. they are recycled), while plastics and mineral-based materials as glass, ceramics and enamel are landfilled and must be considered as lost for future consumption. The present way of disposal, shredding, is considered as relatively satisfying with respect to the materials presently used in stoves. The major part of the energy consumption takes place in the use phase. Irrespective of technology there is a large consumption of fossil fuels with a limited supply adequacy, and future developments in stove technology should focus on reduction of the energy consumption, e.g. by increasing the efficiency of energy conversion. Gas technology uses less primary energy, but new ways of energy conversion, e.g. induction technology, also holds some promise with respect to efficiency.

The major global and regional impacts are caused by the conversion of fossil fuels to energy. An increase in conversion efficiency will therefore decrease these impacts. With respect to local environmental impacts the report points to raw materials acquisition as having the greatest contribution.



Two specific technologies were investigated with respect to their potential health impacts. Use of gas technology causes emission of NO<sub>2</sub> in the kitchen, and a toxicological assessment shows that with the present emissions from gas stoves an increased incidence of airway diseases in susceptible groups (children in densely trafficked areas, asthmatics) must be anticipated. Induction technology was assessed with respect to the potential impacts from electromagnetic radiation. No conclusion was reached because of the lack of information on both exposure and effect. Therefore, the development in this area should be followed closely by both stove producer and toxicologists.

Analysis of the risk of accidents had a low priority as it was shown early in the study period that legal demands and technological development has eliminated the risk of gas explosions when using modern technology. Assessment of the risk of large accidents, e.g. shipwrecking of tankers, was not included in the study.

The general conclusions are summarised below:

- It is impossible to point out one cooking technology as being the best. Instead, product developers must continue their efforts in both development of new technologies and improvement of existing technologies in order to make cooking more energy efficient. In so doing, resource consumption as well as global and regional environmental impacts will decrease.
- Promotion of more energy-efficient technologies must not take place at the expense of an increased impact on human health. It is therefore important to continue the efforts to decrease the emission of NO<sub>2</sub> from gas stoves and reduce the exposure to electromagnetic radiation from induction technology.
- The choice - and amount - of materials for stoves is of relatively small importance as most materials are recycled today. If new materials are developed and used in stoves, it should be taken into consideration whether these are suited to enter the same waste streams as today's technology, or if special arrangements are necessary in order to recycle the materials.
- The consumer can often save the same amount of energy by changing his cooking habits as he can by changing to a more energy efficient technology. The stove manufacturers can help the consumers by developing solutions that are easily implemented in everyday cooking - also for people without a technical background.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0105-3094

ISBN no. 87-78-659-1

# VOC Reduction in the Printing Industry

## VOC-reduktion i grafisk industri

### Miljørapport nr. 339, 1996, Miljøstyrelsen

**In the external environment, volatile organic compounds (VOC) contribute to photochemical air pollution. The environmental effects are transboundary as well as regional. This publication summarises the types of cleaner technology solutions, which are useable for reducing the emission of volatile organic compounds from the printing industry. The structure of the publication is based on the production process of printed matter from prepress to finishing.**

Each chapter covers each printing method and the activities, which contribute to the VOC emissions. Subsequently, the cleaner technologies which can reduce the emissions immediately, and the technologies which imply certain changes of technical, economic or developing characters are described. At the end of each chapter, the traditional cleaning technologies are briefly mentioned as an alternative if the suggested cleaner technology solution is not sufficient.

Today, prepress work is mainly made on computers (electronic data processing) but the processes still include use of photographic materials. For the development of these, the use of VOC is insignificant.

Flexographic printing is the most widely used relief printing method, especially for printing on packaging made of corrugated cardboard, paper and plastics and for wrapping paper, bags, labels, etc. As suppliers develop water washout printing plates the VOC-emission from plate making can be reduced. It is possible to change from solvent-based to water-based flexo inks when printing on paper, cardboard and corrugated board. The use of water-based flexo inks for printing on plastics is possible to a certain degree but a wider use of the technology demands further development. It is expected that it will soon be possible to increase the use of UV-curing flexo inks but development of know-how and large investments are necessary.

As for replacement of VOC rinsing of the flexo machine parts, either high-pressure flushing or ultrasound rinsing can be used under certain conditions.

Letterset is used for printing on plastic buckets and cups. Today, the printing inks are UV-curing and do not contain VOC. However, VOC is used for rinsing the printing machines. Vegetable oil can be used instead when rinsing printing plates, rubber blankets, and inking rollers.

Letterpress is used for printing adhesive labels. The plates for letterpress printing are today washed out with pure water and the printing inks are UV-curing without solvents. The consumption of VOC for rinsing is minor and can be substituted with vegetable oil.

Offset in different forms is used for printing leaflets, catalogues, books, newspapers, magazines, cardboard boxes, tin cans, etc. The emission of VOC derives from alcohol in the fountain water and the use of white spirit and the like for the cleaning of the machines. In tin printing, varnishing causes emission of VOC. However, at manual rinsing it is possible to reduce the use of VOC by substituting white spirit with vegetable oils. The use

of VOC in automatic rinsing can be reduced as new machines fit for cleaning with vegetable oils are introduced.

It is possible to reduce the amount of alcohol in the fountain water or to avoid the use of alcohol in web offset. If the necessary know-how is developed and investments are made on equipment for temperature control, the companies can use a relatively new method, waterless offset where fountain water - and consequently alcohol - is not used.

When successfully developed, water-based or UV-curing varnishes presumably will be used for the varnishing in tin printing.

There is a distinction between publication gravure and packaging gravure when it comes to machines and printing inks. Publication gravure is used for printing magazines while packaging gravure is used for long-term printing of flexible packaging made of paper, plastics, metal foil, and laminates. The emission from publication gravure is reduced by recovering the solvent from the printing ink. The solvents from packaging gravure cannot be recovered.

Cylinder making implies only sporadic use of organic solvents if any.

Water-based printing ink is a potential possibility for VOC-reduction in publication as well as in packaging gravure but the inks are still in the experimental stage. UV-curing gravure inks have not yet been tested.

Powder cleaning or even ultrasound cleaning can be used for cleaning machine parts under certain conditions.

Screen-printing is used for printing signs, posters, labels, t-shirts, etc. It can be used for printing on paper, plastics, textiles, glass and metal. Solvents are only used sporadically for the stencil making.

It is possible to use water reducible screen printing inks for printing on thick paper and cardboard. Water reducible as well as UV-curing inks can be used for printing on certain types of plastics (PVC, PC, PS, acrylics and possibly more) if the surface is well treated. The use of UV-curing inks implies investments in UV-lamps and can cause health problems for the workers. The use of water-based or certain water-reducible UV-curing screen printing inks open a possibility for using waterbased cleaning agents.

Solvent waste from the cleaning of screen printing frames can be regenerated if the necessary equipment is installed.

Finishing of printed matter includes gluing, varnishing and laminating. Gluing causes an insignificant use of solvents.

VOC emission can occur from the adhesive when printed paper is laminated with a thin plastic film. There is no immediately useable solution in the form of cleaner technology.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0908-9195

ISBN no. 87-7810-541-2

# Test of Glass Collection by Colour Separation

## **Test af glasindsamling med farveseparering Miljørapport nr. 340, 1996, Miljøstyrelsen**

**The aim of the tests in the present project is to increase the re-cycling of collected glass from the present 60-65% to 80%. The project is designed to optimise the collection of glass and the colour sorting in a span of four years.**

In April 1994, a one-year long test with colour-separated container collection of glass was launched. The test includes 10 local authorities east of the Great Belt, in total 140,000 households. The local authorities are:

- Holbæk and Nykøbing-Rørvig
- Ølstykke, Stenløse and Hundested
- Frederiksberg and Copenhagen
- Ballerup and Herlev

Concurrently with the project, an information campaign about colour sorting in the respective local authorities was launched.

The project contains a summarised evaluation of the results of the project, a general conclusion and recommendations for the implementation of the system on national basis. The appendix illustrates the technical part of the project.

The summary of test results describes how the evolution of the collected volume of glass was affected. Subsequently, the factors that influence the volume of collected glass are discussed. Wrong sorting and the reasons for it are also discussed. Finally, suggestions to how the results from the ten local authorities can be used for the implementation of colour separation on a national basis are listed.

The economic consequences of the tests are evaluated. The following factors are evaluated:

- Expenses for collection and transportation in connection with the glass collection
- Expenses for information
- Settling prices
- Depreciation and maintenance of containers
- Costs in connection with collection of transparent glass

On the basis of these registrations, a calculation example of the economic consequences of colour sorting on a national basis is made.

The present and future co-operation relation between the local authorities and the re-cycling industry is estimated on the basis of the daily operation system. The estimation is realised for the local authorities of the test and on national basis, in case a national colour-sorting system should be implemented.

The results of the test are presented below:

- All local authorities of the test have had an increase in the volume of collected glass in the test period compared to the year before.
- On average 10% more glass has been collected compared to the year before.
- The quality of the collected glass has been varying. The best results have been achieved in places where containers with different colours were set up.
- It does not seem to be possible to minimise the wrong sorting.
- All container stations should have containers for both coloured and transparent glass. Containers should be placed where they are easily accessible and where there are many people.
- Colour sorting will increase the costs, which derive from the collection of glass.
- The information campaign did not prove satisfactory.

The final result of the test is a suggestion to implement colour sorting on a national basis, including prerequisites, efficiency, quality, choice of container, pre-sorting, economic consequences, total additional costs, balance sheet, marginal costs, and information.

Furthermore, four different colour-sorting systems, which can increase the collection of glass to the desired 80%, are evaluated.

Finally, a number of considerations in connection with the implementation of the colour sorting systems on national basis are discussed.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0105-3094

ISBN no. 87-7810-667-2

# Environmental Screening of Milk Wrapping

## Miljø-mæssig screening af emballage til mælk Miljørapport nr. 345, 1996, Miljøstyrelsen

**During the past 6 months the debate on milk carton wrapping has become fiercer. In Denmark there are two different types of wrapping: Laminated gable-top cartons, and plastic cans made of HDPE (High Density Polyethylene). The aim of this project is to describe the environmental impacts of each of these two types.**

The environmental evaluation is done on the screening-level, which means it is based on already existing literature data. Specific data from Danish producers has not been collected, which means that the screening does not cover all relevant Danish conditions.

The examination/ evaluation provides insight into:

- The type of environmental impact for each system
- The size of particular impacts in each system
- Areas where knowledge about the two systems is lacking
- A preliminary indication of pros and cons of each wrapping system
- Results from relevant research on milk wrappings from Denmark's neighbour countries.

The screening cannot be used to evaluate which system is most environmentally sound, but does give an indication of the pros and cons of each system and points at the most important environmental conditions.

The environmental evaluation consists of:

- A description of aim and system limitation
- A summary of resources, emissions and waste
- An environmental evaluation where the results from the summary are recalculated to resource consumption and environmental effects (greenhouse effect, acidification, toxic effects etc.)

The final waste deposit is used as an indicator of the environmental effects the deposit of waste can cause. (E.g. ground water pollution)

The environmental effects are presented as *potential* environmental effects. The actual environmental impact is dependent on the circumstances. In the environmental evaluation the potential environmental effects are valued as:

- Greenhouse effect
- Ozone layer breakdown
- Acidification (Acid rain)
- Nutrient salt burden
- Photochemical ozone creation
- Human toxicity via air
- Waste volume
- Dangerous waste
- Radioactive waste

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ISSN no. 0105-3094

ISBN no. 87-7810-674-5

# A Guide to Environmental Management in Power Stations

## Håndbog i miljøstyring for kraftværker Arbejdsrapport nr. 2, 1996, Miljøstyrelsen

**Environmental management is a tool that many companies will implement as part of their environmental work in the years ahead. The aim is partly to improve the environmental conditions and to implement cleaner technology in the companies and, partly, to be able to provide the necessary documentary proof of the environmental conditions for the external environment, e.g. through green accounts. This report is a guide to implementation of the environmental management tool in power stations.**

The examples in the guide are taken from Sønderjyllands Højspændingsværk (The High Tension Power Station of South Jutland), where the employees, step by step, were taken through a course on environmental management to the green account. The intention is that the guide should be used by Danish power stations and other supply plants who work on implementing environmental management and on using cleaner technology to the benefit of the environment.

The guide is aimed at both the management and the employees at the power station. Each part plays their own role in the environmental management process and can use the guide for different purposes.

The guide is divided into four phases of environmental management. To begin with, chapter 2 describes the initial phase, including, the support of the management, the preliminary studies and the organisation chart of the station.

Subsequently, the phases are presented step by step:

- Chapter 3 and 8 describe the tasks of phase 1: The planning
- Chapter 4 and 5 describe the tasks of phase 2: SWOT analysis
- Chapter 6 describes the tasks of phase 3: Evaluation
- Chapter 7 describes the tasks of phase 4: Implementation

On the basis of the preliminary studies, concrete goals for reducing the actual environmental impacts are set. The functions of the power plant are given priorities. Together with the established goals, the priorities constitute the basis for the SWOT analysis in phase 2.

First part of phase 2 maps out the environmental situation. Second part of phase 2 includes the priorities and the establishment of goals. The environmental general survey contains a systematic data collection for the function of the power station, which was chosen in the preliminary study. In the general survey the incoming and outgoing materials and energy flow are described systematically so that priorities can be made. The general environmental survey is the basis for the selection of concrete action areas and the suggestions to how these can be handled.

When a number of suggestions to the action areas are listed and described, it is necessary to evaluate them. The actual situation is compared with suggested alternatives as regards to environmental, technical, and economical conditions. The evaluation is based on the



processes and conditions of the power plant, which lie within the frames of the plant. The evaluation phase concludes with a written statement, in which the most important aspects of the evaluated situations are highlighted. The statement contains suggestions to and a list of priorities of future action areas and is part of the management's basis for decision, when environmental improvements are considered.

The implementation phase builds on the results of the evaluation. Phase four therefore contains:

- Implementation of the chosen solutions
- Evaluation of results
- Formulation of environmental policy
- Drawing up of an action plan for the course of coming environmental management projects

Thus, the results of phase 4 are the conclusion of the first course of environmental management and an action plan for the forthcoming environmental management project.

At present the power plant has gone through the environmental management cycle only once. From the implementation of environmental management to the completion of the first evaluation of results. Now the time has come to formulate environmental policies, environmental goals and an action plan for the next period, that is a new cycle. In the new cycle it can be relevant to formulate new or change the environmental policy in relation to the first cycle.

Finally, the demands for how the green accounts should be prepared are presented.

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This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-9195

ISBN no. 87-7810-528-5

# Development of Lock Systems for Dry Transportation in the Beluga Processing Industry

## Udvikling af slusesystemer til tørtransport i hvidfiskeindustrien Arbejdsrapport nr. 8, 1996, Miljøstyrelsen

The beluga processing industry contributes considerably to pollution when offal from the fillet lines is washed away. In the present system, which is based on water transportation, the fish offal is washed out during the transportation, which causes organic compounds in the wastewater in the subsequent separation in spiral and rotosieve.

In order to change these conditions in the fish processing industry, further actions for development must be taken. Earlier projects completed in the fish processing industry have shown that the implementation of vacuum transportation systems and suction apparatus at the fillet lines results in cleaner technology.

Based on the experience derived from earlier projects, the purpose of this project is to develop a new technique for transportation of offal. The technique intends to let in the offal gradually at the fillet line and to sluice it out from a vacuum transportation system.

The practical part of the project was carried out in the period January 1994 – July 1994.

In order to start the development of locks, the water consumption at the test line has to be reduced to a minimum consumption. The report describes how water savings systematically are gained on all parts of the fillet lines. That is the head cutter, the filleting part and the skinning part. The results are presented schematically.

After the presentation of the water savings, the report describes how the construction of a separation system for the lockage funnel and the vacuum plant is made.

The results of the reductions of different parameters with and without the vacuum system are presented below.

Parameter kg/h	Without vacuum system	With vacuum system
BOD	6,6 +/- 0,4	2,3 +/- 0,4
COD	12,3 +/- 1,6	4,1 +/- 0,5
Total-N	0,95 +/- 0,14	0,38 +/- 0,06
Total-P	0,189 +/- 0,024	0,062 +/- 0,007
Dry matter	12,0 +/- 0,97	3,6 +/- 0,5
Ashes	3,3 +/- 0,97	0,57 +/- 0,1
Water consumption m <sup>3</sup> /h	2,2 +/- 0,36	0,73 +/- 0,07

The offal from the two transportation systems – water and vacuum – is evaluated according to its ability to maintain quality. The offal is kept in cold storage for 48 hours, after which

the total volume of nitrogen is measured on day 1 and 2. The results of the evaluation, in which offal and drippage are measured after 24 and 48 hours, are illustrated below.

Offal: Coalfish	TVN mg N/100g	g TS/kg	mg N/g TS
Results	24 hours – 48 hours	24 hours – 48 hours	24 hours – 48 hours
Drippage from normal	24,0 – 35,3	38,8 – 41,1	6,2 - 8,6
Drippage from vacuum	45,2 – 51,4	62,4 – 66,8	7,2 – 7,7
Normal offal	37,3 – 48,6	191 – 200	2,0 – 2,4
Offal with vacuum	37,6 – 48,8	191 – 191	2,0 – 2,6

The energy consumption in the present offal plant is compared to the new vacuum plant. Moreover, for each type of plant the resource consumption in relation to investment in new equipment, savings in water costs and water purification costs and earnings derived from the sale of increased offal volume are estimated.

The project concludes that the implementation of a vacuum system for sluicing of fish offal results in a smaller impact on the environment, and, consequently, green taxes are saved. When employing the vacuum system, the water consumption and the environmental impact are reduced by 65%. This reduction means a cost saving in the wastewater taxes and an additional income because of the increased volume of offal. At the same time the work environment is improved, as humidity and water on the floor areas are reduced. Employment of the vacuum system does not change the energy consumption.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195  
ISBN no. 87-7810-537-4

# Elimination of Organic Wastewater from Organic Batch Production

## Elimination af organisk spildevand fra organisk batchproduktion Arbejdsrapport nr. 9, 1996, Miljøstyrelsen

**The general purpose of this project is the recovery of 80% organic solvents and the reduction of A/S GEA's water consumption of 2,000-3,000 m<sup>3</sup> per year. This report maps out and evaluates the possibilities of technical solutions and their impact on the environment, energy and economy.**

The project is divided into three sections. The first section contains the development and construction of a pilot plant. The second section contains a theoretical investigation of the pilot plant together with a determination of how the plant works and which factors are decisive for its effect. The final section describes the pilot plant tests, which aims at the practical aspects and the efficiency of the plant.

The solution concept, which is based on changing the service liquid from water to oil, is indeed applicable. The change of the service liquid makes it possible to make a substantial reduction of the water consumption through the substitution of water. Furthermore, the recovery of the solvents is simplified, as the steam from the production only enters one fraction.

Experience from practical and technical details, as regards to the solution concept and the pilot plant, has been gathered. In order to find and evaluate the solutions, technical literature, investigations and tests were used.

The over-all impression is the following:

- It is technically possible to eliminate the solvents and reduce the water consumption
- Solutions should be made in accordance with the type of solvent, the existing equipment in the production area, and the production programme
- Recovery of solvents and reduction of water consumption, dependent on the product programme and the production methods, can be a successful approach.
- Future requirements to the environment can only be met if the producer reduces, and in the long term, eliminates the disposal of liquid.

A condition of an efficient use of the concept is the specific type of solvent, which is used. The solvents can be divided into three groups with a high, medium and low steam pressure. The higher the steam pressure of the solvent, the more applicable is the solution concept, as the level of evaporation increases with the level of the steam pressure.

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This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-9195  
ISBN no. 87-7810-541-2



# Elucidation of the Environmental Advantages of Using Transport by Sea as Opposed to Rail or Road Transport

## **Belysning af de miljømæssige fordele ved coastertransport frem for landtransport**

**Arbejdsrapport nr. 13, 1996, Miljøstyrelsen**

**The purpose of this project is to explain the environmental aspects of transporting goods by sea, rail or road, and to look into which way of transporting is the most suitable one.**

Calculations show that it is possible to obtain a considerable saving in energy and environmental emissions, if transports of goods are shifted from road transport to transport by rail or sea.

The preliminary work shows that the energy consumption is twice as high by using rail transport instead of transport by sea, and twice as high when using road transport instead of rail transport. This means that the energy consumption is four times higher when goods are transported by road instead of using transport by sea.

When the energy consumption is reduced, the amount of environmental emissions such as the emission of carbon dioxide (CO<sub>2</sub>) is reduced too. This is also the case when it comes to emissions of other related environmental components such as particulate matter, nitrogen oxides, carbon monoxide and total organic carbon.

However, on one point transport by sea is not the best environmental solution: The emission of sulphur dioxide (SO<sub>2</sub>) is at a comparatively high level when transporting by coaster. This results from the use of fuel of a less quality than fuel used by trains and lorries. Coasters operating in Danish and European waters normally use gas oil with a sulphur content of 0,2 %. Fuel, gas and oil, used by rail and road transportation have a sulphur content as low as 0,05%.

In Denmark 94 % of all domestic transportation of goods is carried out by road. This means that the potential for major reductions in energy and environmental emissions is present if transport could be shifted from road and out to sea.

Other factors as traffic accidents, noise nuisances and costs to maintenance of roads and railway lines will be reduced if a larger part of the goods could be transported by sea.

It is the author's opinion that coasters are fully capable of delivering goods "just in time" precisely as lorries.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-559-5

# Recovery of Process Bath of Chromic Acid

## Genvinding af chromsyreholdige procesbade

### Arbejdsrapport nr. 17, 1996, Miljøstyrelsen

**In 1991 MILJØ-KEMI made a preliminary project on recycling of chromatin baths by membrane electrolysis. The project identified several possibilities of using the method for cleaning and regeneration of process baths based on chromic acid. This has been the basis of this project, which includes a practical test of membrane electrolysis in both lab-scale and full-scale.**

Recovery of process bath with chromic acid is an important element by introduction of cleaner technology in the electroplating industry and related industries. By using this recycling technique process chemicals will be saved and the amount of chemical waste will be reduced. The preliminary project indicates that this method in some cases also will save money for the industry. At the same time the solution will create possibilities to establish partly closed systems without emission of wastewater and waste.

Chromic acid is the key component in chromatin baths. When metal items of zinc and aluminium are treated in the bath a chemical reaction is taking place on the metal surface where a corrosion resistant layer of chromate is formed. Metal is removed from the surface and this metal - typically zinc and aluminium - will accumulate as metal ions in the process bath as a pollution. At the same time some chromic acid is reduced to chromium(+3). Therefore new chromic acid must be added to the bath. When the concentration of metal ions and chromium(+3) has reached an unacceptable level the bath is discarded. By treating the bath in a membrane electrolysis cell the bath can be reused.

The pollution of a chromium bath and a chromic acid pickling bath is nearly the same. Metals are accumulated in the baths, where also some chromium(+3) is formed. The pickling bath is used for etching of aluminium surfaces. The chromium bath is used for electrolytic depositing of bright chromium layers on items of steel, copper and brass.

Lab-tests have been carried out on the cleaning and regeneration of chromatin baths and chromic acid pickling baths, because no practical experiences were available. The test has produced valuable results and knowledge about the possibilities of this recycling method.

There have also been made investigations of 2 full-scale plants - one for recycling of a bright chromium bath and one for recycling of a yellow chromatin bath for zinc. These investigations show that the method does work, but considerable amounts of chromium are lost by the treatment dependent of the degree of pollution.

Yellow chromatin baths for zinc normally contain a lot of chloride which is oxidised by the anode in the electrolysis cell. Hereby a heavy chlorine emission is taking place, and this problem must be solved before the method can be used in practice. Chromatin baths with chloride should be treated batchwise, and effective ventilation from the cell is needed. The bath should not be kept in the production area during treatment, because this will cause chlorine gas in the production hall

Chlorine problems can be solved by using chloride free chromatin chemicals with nitric acid instead of hydrochloric acid. After all there is a long tradition for using hydrochloric



acid to obtain a special yellow appearance and a good corrosive resistance of the treated surface. Tests have shown that this can be done using nitric acid, too.

Even if the project has exposed some problems by using membrane electrolysis for regeneration of process baths based on chromic acid we have seen that the equipment can function. It should after all be possible to optimise the equipment and system. Alternative catholytes should be tested and oxidation of chromium(+3) should be improved. Furthermore the operation routines must be optimised and systematised to obtain a complete and quicker removal of metals from the bath.

The preliminary project disclosed that foreign suppliers only have experience of membrane electrolysis for treatment of bright chromium baths. Nobody has tried to regenerate chromatin baths and chromic acid pickling baths for zinc and aluminium. This project has clearly demonstrated that these baths also can be regenerated. The first full-scale plant has already been established by Astral Galvano for regeneration of a yellow chromatin bath for zinc. With this cell 2/3 of the chromatin chemicals are recovered instead of sending the discarded baths to Kommunekemi.

By chromatin most of the process chemicals are lost to the wastewater, and the plan for the future must be to recover these chemicals too. This may be possible by a combination of counter current rinse and nano-filtration in a closed loop. Hereby we obtain a concentrate, which can be treated by membrane electrolysis and sent back into the process bath. It could be a future cleaner technology solution, which is more complete than just treating the discarded baths.

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This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-9195

ISBN no. 87-7810-562-5

# Advantages and Disadvantages in Connection with the Usage of Rainwater in Households

## Fordele og ulemper ved anvendelse af regnvand i husholdninger

### Arbejdsrapport nr. 18, 1996, Miljøstyrelsen

**This report aims at describing the advantages and disadvantages in connection with usage of rainwater in households. The project estimates the environmental impact of the usage of rainwater compared to the situation of the water supply, the pollution from systems of discharge pipes and treatment plants. Furthermore, the health aspects, the technical aspects and the financial aspects linked to the usage of rainwater are discussed.**

Usage of rainwater in households implies that less ground water has to be collected. However, ground water resources as well as consumption vary according to different parts of the country. In areas where the consumption of ground water is close to the available ground water resources, the usage of rainwater will be useful to the drinking water resources. In the metropolitan area for example, the consumption is by far exceeding the ground water resources.

A general usage of rainwater from roof surfaces could reduce the water consumption of the households by approx. 18 %.

The usage of rainwater implies that discharges of diluted wastewater from combined sewer systems (through overflow structures) to lakes and streams will be reduced. For separate rainwater systems the discharges will be reduced as well.

The discharges from treatment plants in connection with rainfalls will be reduced when part of the rainwater in the catchment area is used. Calculations in the report, carried out on the basis of a theoretically simple catchment area, show that the result will be from 1 to 10 % reduction of the total water and pollutant loads discharged. Generally, the environmental influence in relation to discharges conditioned by rainwater is dependent on the extension of the usage of rainwater.

Percolation of rainwater is having a similar environmental influence in relation to formation of the ground water and discharges conditioned by rainwater from the sewer systems. Consequently, it would be natural to combine the various potentials so that the environmental influence is as large as possible. This could for example be done by collecting and using rainwater from roof surfaces and build in overflows from the rainwater tanks to soakaways, where the excessive rainwater can percolate.

From a health point of view, there are a number of disadvantages by using rainwater from households.

Rainwater collected from roof surfaces might, among others things, contain microorganisms from animals, and moreover chemical substances from the atmosphere can be found in rainfalls. Finally, substances from the material of the roof surfaces might occur.

There is a potential risk that a mixture of rainwater and drinking water might pollute the drinking water supplies. Consequently, in theory there is a risk of illness cases as a consequence of usage of rainwater. There are, however, no examples in practice of infections of illness from rainwater systems.

It is possible to establish areas without separate rainwater systems for discharge of rainwater.

The lower degree of hardness in rainwater implies that less soap has to be used in connection with laundering.

A number of technical conditions must be considered in connection with establishment of rainwater systems: Change of piping arrangements, space requirements, corrosion of pipe and tank material, bottom sludge, formation of algae, inspection and maintenance, marking of pipe system, etc.

It will be necessary to provide the tank with drinking water in periods without rainfall events. In this connection it must be ensured that reject flow to the drinking water system does not take place.

From a socio-economic point of view, it does not pay today to establish systems for usage of rainwater in households. It is cheaper to collect ground water from other places in the country for areas with heavy loads or to carry out simple water-saving measures. In relation to the sewer systems, the costs in connection with usage of rainwater can be more than 10 times larger than for other environmental measures, for example tanks in the sewer systems or local percolation. In some cases, however, where it is very expensive to build tanks, calculated in relation to the result obtained, usage of rainwater could be a more profitable possibility.

From a private economic point of view, it normally pays to make systems for usage of rainwater in households. The repayment time with the present water rates will, under favourable conditions, be 20 years. As, however, the usage of rainwater is highly contributing to a more green character to a house or a building the usage is in practice often not conditional on profitability.

The utilisation of rainwater seems to be a solution, which can be beneficial to the environment: less ground water is collected and the discharges conditioned by rainwater from the sewer system are reduced. There are, however, certain conditions, which imply that an extended usage of rainwater could be a possibility. However, in many situations the lack of drinking water can be remedied in cheaper ways. In cases of an increased pollution of the ground water, these conditions might however change.

Furthermore, it is a fact that if we also wish to maintain the installation standard and the health and sanitary level for rainwater installations which we have in the remaining water installation, it will be difficult to make a rainwater installation today which is profitable.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0908-9195  
ISBN no. 87-7810-566-8

# Environmental Evaluation of Beer and Soft-Drink Containers

## Miljøvurdering af emballager til øl og læskedrikke Arbejdsrapport nr. 21, 1996, Miljøstyrelsen

**This report is based on a wish to fulfil an environmental evaluation of beer and soft drink containers since these containers have, until now, not been directly comparable. The evaluation consists of a mapping of resources, energy consumption, emissions and waste and consequently a calculation of the effect these have on the surrounding world.**

The project “An Environmental mapping of Beer and Soft-Drink Containers” started with a literature review and screening in the autumn of 1992.

Since then several steps have been taken: Firstly a mapping of beer containers, thereafter a quality estimate of these, followed by a mapping of soft-drink containers and a quality estimate follow-up.

The aim of this project is to expand the existing mapping of containers with an environmental estimate, which means a re-calculation of emissions to potential environmental effects and an evaluation of the resource use. This would provide a more satisfactory platform from which an evaluation of the possible environmental effects of the containers can be taken, and from that make a list of the advantages and disadvantages of different containers.

When the project started it was common practice to carry out environmental estimates through mappings – the method of recalculating emissions to environmental effects was still being developed. The results of these mappings was discussed qualitatively through the quantity of emissions and waste, but it was difficult to make any final conclusions since it was impossible to determine whether one emission was more critical than another

Since then the UMIP-method, (in English DMFIP – Development of Environmentally Friendly Industrial Products), has been developed and has reached an internationally high level of quality. The mapping of beer and soft-drink containers is therefore converted to potential environmental effects via this method.

The results have been passed on to the Environmental Agency and include:  
An evaluation of the use of resources  
An evaluation of potential environmental effects (including waste as an indicator of the effects waste disposal can have)

Since beer and soft-drink containers do not have the same volume, it is not possible to compare absolute values. On the other hand it is possible to compare the relative tendencies. The resume also contains an estimation of the effects when using the average European electricity production, instead of place specific electricity production values.

In general the largest contributions are found in disposable bottles made of PET, glass and steel tins, and the lowest in recyclable bottles made of glass and PET, and in aluminium tins. The replacement of the electricity scenarios means that the contribution to environmental effects is becomes larger for aluminium tins, whilst it does not significantly change for all other types of containers. The change is most important with regards to the

greenhouse effect. Aluminium tins are thus found in the middle of the scale instead of the lower end.

The eco-toxicity in water – both chronic and acute - give the largest weighed values of toxicity compared to other categories. A clear difference between the different types of containers cannot be proven. This is due to, on the one hand, the large insecurity in estimating toxicity, and on the other hand that the used data on all the types of containers mainly comes from the energy production.

The lowest contributions come from the recyclable PET-bottles. Aluminium and steel tins constitute a large amount of dangerous waste, and disposable bottles constitute the largest contribution to slag and ash. Radioactive waste is largest in aluminium- and steel tins and in PET-disposable bottles. Glass containers (disposable and recyclable) and recyclable PET bottles give the lowest contributions. Swooping between electricity scenarios does not change the general picture, but the amount of radioactive waste will, in general, increase.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-587-0

# Data Descriptions of Ongoing and Completed Life-Cycle Assessments

## **Datablade for igangværende og gennemførte livscyklusvurderinger**

### **Arbejdsrapport nr. 23, 1996, Miljøstyrelsen**

**This report contains a number of data descriptions of ongoing and completed projects concerning life-cycle assessments. The projects have been carried out by a line of Danish advisers and institutions from the reference group of the Danish Environmental Protection Agency (Miljøstyrelsen) dealing with life cycle assessments and protection of environment during the process of developing new products.**

71 key diagrams form the assembling of data descriptions, and they are listed in alphabetical order by institution and each institution has its own section. A subject index has been worked out and placed after the schemes in the report. It states which industries, enterprises and products are included in the data descriptions. The content of schemes has not been edited but includes primarily specific projects that have been carried out by own means or with support from public or private commissions. Furthermore schemes for a few institutions have been made, which summarise course activities and examination projects dealing with life cycle assessments.

Data descriptions from the following advisers and institutions are listed in the report:

- dk-TEKNIK
- DTI
- Institut for Teknologi og Samfund
- Econet
- IPU
- Krüger Consult A/S
- SBI

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-580-3



# Development of an Instrument for Evaluation of Companies' Environmental Action

## Udvikling af værktøj til evaluering af virksomheders miljøpræstation

Arbejdsrapport nr. 25, 1996, Miljøstyrelsen

**The purpose of this project is to define a general Danish instrument for evaluation of companies' environmental action. The project investigates the possibility of establishing simple and functional guidelines for environmental management in small- and medium-sized companies at trade level or part trade level. On the basis of these, a guide in defining trade standards of environmental action is worked out.**

The background of the project is that the Danish Association of Consulting Engineers (Foreningen af Rådgivende Ingeniører) in connection with the hearings made by the Danish Environmental Protection Agency (Miljøstyrelsen) concerning the EU' s Eco Management and Audit Scheme (EMAS) in 1993, have pointed out the necessity of developing general guidelines to the evaluation of environmental performances in Danish companies. The instrument should be a presumption of a successful implementation of the EMAS regulation in Denmark.

The project focuses on the graphical industry as well as the wood- and furniture industries. The reason is that these industries possess a well-established database on environmental conditions. At the same time many small companies constitute the industry as a whole.

The project is aimed at the companies and industries, which on a systematic foundation, work on introducing cleaner technology and environmental management, Danish authorities that work on establishing appropriate rules for environmental management in companies and organisations, and Danish participants in European and International work on standardisation of environmental management.

In the project is presented: The general instrument to the evaluation of the companies' environmental actions as well as the procedure at the start-up of the project. Furthermore a test of the instrument in the graphical- and in the wood- and furniture industries is examined.

It is possible to establish a Danish instrument to evaluate the environmental action of companies. The tested industries are positive and have assessed that the instrument will be able to help many companies who wish to improve their environmental action. At the same time it is concluded that the establishment of instruments for use in small- and medium-sized companies can also be used in other industries. The results of the project may have important influence on the future of the continuing development on the areas: Environmental management, environmental statement and environmental accounts in Denmark.

The project will be implemented in a general guide, which is published separately as: The environmental project "Instrument for Evaluation of Companies' Environmental Action" (Miljøprojekt: "Værktøj til evaluering af virksomheders miljøpræstation").



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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-477-7

# The Environmental Impact of a Family's Activities

## **Kortlægning af miljøbelastningen ved en families aktiviteter Arbejdsrapport nr. 26, 1996, Miljøstyrelsen**

**The purpose of mapping out the impacts of a family's activities is to create an environmental budget, which can be used as a tool for consumer organisations working with providing information on consumption and environment. This method report presents the data material, which was used in connection with the mapping out of the environmental impacts of a family's activities and describes the basis of calculation, which was used in order to reach the results of the inquiry.**

The mapping out of the environmental impacts of a family's activities is described in a method report published by The Danish Environmental Protection Agency. The National Consumer Agency of Denmark published the results of the inquiry in 1996.

The project is based on consumer data from the National Consumer Agency. The basis for the calculations is the Agency's budget for a role-model family consisting of two adults and two children. The calculation includes typical consumer data such as electricity, water and heating data. Moreover, a simplified life-cycle assessment of the environmental impacts of the role-model family's use of 812 different products distributed by 22 different activities was carried out.

The result of each activity is presented as an environmental profile for the resource consumption and the emissions to the environment. Moreover, the results are divided into three sections: Production, use and disposal.

The applied model for simplified life-cycle assessments of a large number of products is presented in the method report. The fact that the assessment is simplified means that the environmental data consists of single processes for materials with typical process cycles. The resource consumption and the emissions to the external environment in the process of manufacture, surface treatment and the disposal of the products are calculated as additions which, based on typical single processes for the processing and the surface treatment of the material, are given to each product. In the definition of the additional processes, importance was also attached to limiting the number to only a few options. Additions for the disposal also cover the crediting of the materials which are included in the products and which are recycled to a wide extent.

The family's consumption of resources and emissions to the external environment are stated in person equivalents. A person equivalent is the average resource consumption for a person in a year or the average emission of environmentally dangerous substances of one person in a year to the external environment.

The results of the analysis show that the family meals constitute a third of the total consumption of resources and emissions to the external environment. Car transportation and heating of rooms also constitute a third of the family's resource consumption and emissions to the external environment.

The remaining third of the resource consumption and emissions to the external environment especially concerns the consumption of goods in spare-time occupations, clothing, hygiene, health care and cleaning.

All together the family's total consumption of water, oil for heating, gasoline for transportation constitute more than half of the family's consumption of resources and emissions to the external environment. The areas where environmental benefits could be gained are areas where the consumers have great influence on the size of the consumption. However, this requires a change in our daily consumption pattern in a number of areas.

As regards to the chemical household goods an inquiry into the impact on the water environment was made. The assessment is based on the role-model family's use of goods and the eco-toxicological effects of the substances. Laundry detergents, hair care products, shower gel and lavatory washing products cause the most serious impacts.

The result report focuses on presenting the environmental impacts of the family's activities. From the background material of the project it is possible to extract the environmental impacts from the 812 investigated products included in the family's activities.

For the handling of the large amount of data, a database system in the PC programme Paradox was developed. The project's data files can be required on discs by contacting The National Agency of Environmental Protection.

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This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-9195

ISBN no. 87-7810-583-8

# Cleaner Technology Projects 1993 - Summaries

## **Renere teknologiprojekter 1993, resumeer Arbejdsrapport nr. 30, 1996, Miljøstyrelsen**

**Cleaner Technology Projects 1993 – Summaries is a work report with summaries of all 42 environmental projects and work reports made by the Danish Environmental Protection Agency (Miljøstyrelsen) about cleaner technology, which were published in 1994.**

Two publications from the Danish Environmental Protection Agency with relevance for the effort of cleaner technology, in the shape of a report from the “North Jutland Framework Program” (Nordjyske Rammeprogram) - published in the series “Guidance from the Danish Environmental Protection Agency” (Orientering fra Miljøstyrelsen) – and the handbook “Chemical Cleaning Processes” (Kemiske Afrensningsprocesser) – published in the series of “Environmental News” (Miljønyt-serien) have been included.

The projects were carried out according to the action plan “Cleaner Technology 1993-97” made by the Danish Environmental Protection Agency (Miljøstyrelsens handlingsplan for Renere Teknologi 1993-97).

In 1993, more than half of the subsidies was used for industrial processes. Out of an aggregate allocation of 76 Mio. DKK 35 millions DKK went to projects within this field, while 10 Mio. DKK were used on projects focusing on products.

The keywords for the efforts made in 1993 were limitation and reduction. Limitation of the direct environmental impacts of production, consumption and disposal of goods – e.g. by substitution of environmental damaging substances and materials, and reduction of the consumption of the nature’s resources and energy.

The environmental conditions have increasingly become competitive parameters for the companies. The introduction of cleaner technologies has demonstrated to cause operating savings and lower production costs, and these experiences have been provided e.g. through the project reports.

Cross-references have been given for the projects, which are part of important examinations or if a preceding or following project exists.

Since the work reports are only published in a restricted circulation some may no longer be available. These can be borrowed from the library of the Danish Environmental Protection Agency. The environmental reports can be bought through the Danish Environmental Protection Agency or in the “Environmental Store” (Miljøbutikken) or borrowed at a public library.

This collection of reports has also been published in English.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-598-6

# Cleaner Technology Projects 1994 - Summaries

## **Renere teknologiprojekter 1994, resumeer Arbejdsrapport nr. 31, 1996, Miljøstyrelsen**

**Cleaner Technology Projects 1994 – Summaries is a work report with summaries of all 43 environmental projects and work reports made by the Danish Environmental Protection Agency (Miljøstyrelsen) about cleaner technology, which were published in 1994.**

The projects were carried out according to the action plan “Cleaner Technology 1993-97” made by the Danish Environmental Protection Agency (Miljøstyrelsens handlingsplan for Renere Teknologi 1993-97).

In 1994 focus was set on the concept of life cycle as a principle in the preventive environmental work. Furthermore, many of the projects dealt with lateral provision – in an industry, among companies with mutual presentation of a problem or within the same geographical area. Finally, environmental management was a subject for several projects.

A general feature of most of the projects was that it pays off for the companies to work targeted with cleaner technology as a preventive effort – the investments are quickly earned and the technological development can also produce export advantages.

Cross-references have been given for the projects, which are part of important examinations or if a preceding or following project exists.

Since the work reports are only published in a restricted circulation some may no longer be available. These can be borrowed from the library of the Danish Environmental Protection Agency. The environmental reports can be bought through the Danish Environmental Protection Agency or in the “Environmental Store” (Miljøbutikken) or borrowed at a public library.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-597-8



# Cleaner Technology and Recycling at Frigodan, Orehoved and Frigodan, Svendborg

## Renere teknologi og genbrug på Frigodan, Orehoved og Frigodan, Svendborg

### Arbejdsrapport nr. 32, 1996, Miljøstyrelsen

**There is a tradition that the process water from the vegetable food industry is eliminated by ejection or by purification in biological purifying plants. Both solutions are connected with technical and practical problems. This projects aims at clarifying - by means of physical and chemical processes - whether it is possible to purify the process water to an extent that it can be recycled in the firms.**

The food industry is characterised by seasonal production with a large water consumption, which means that a purifying plant should be able to manage varying loads. Moreover, the purifying plant has to be made ready for the season by adding a substance with another composition than that of the actual process wastewater. As the firms in the food industry are often large, the load will be heavy and rather varying. This fact will require large investments in machinery.

The results of the project are illustrated in figures that are enclosed as appendix in the project.

The water consumption, defrosting of freezers, and refrigerating plants are described for Frigodan, Orehoved and Frigodan, Svendborg. Suggestions to water-saving measures are made. Where it was possible, the expected profit is stated.

The energy consumption of electricity and gas in Svendborg is revised for all products and consumption places. Apart from the total annual energy consumption, the electricity and gas consumption per ton-finished goods is also stated and commented on. As regards to Orehoved, the total consumption of electricity, gas and oil is revised.

Considering the limitations of upgrading the results of the test plant to a full-scale plant, the following conclusions can be made:

- It is possible to evaporate an average water flow from the firms so that the condensation can be recycled in the production.
- With a number of process-water flows it is possible to achieve a water quality, which complies with the water requirements.
- Ejection or recycling in selected parts of the production is very likely to take place immediately; if the evaporation occurs in a plant specifically constructed for the purpose.
- The content of bacteria and embryo in the condensate was always situated below the drinking water requirements.
- Tests with flotation/sifting/RO filtration resulted in an out-flow from the RO filtering, which can neither comply with the drinking water requirements nor be drained of.



- Concentrate from the above processes can be used as fertiliser in the agriculture, and, in some cases, as feed.
- The estimated costs of the above solutions are higher than the traditional solutions. However, audits of draining taxes or green taxes can change this picture. In addition, the firms' possibilities of increasing the production, while avoiding a corresponding increasing environmental impact, and the social value of the solutions must be taken into account.
- Especially at Frigodan, Svendborg there was a possibility of reducing water and energy consumption considerably. In some cases, the measures were relatively simple, and, in others, significant changes in the existing productive equipment had to be made. This picture is likely to be general for this type of firm.

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Hedeselskabet

This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-9195  
ISBN no. 87-7810-599-4

# The Recycled House – Cleaner Technology – Working Report

## Det genanvendte hus – renere teknologi Arbejdsrapport nr. 34, 1996, Miljøstyrelsen

**The construction industry is responsible for a large part of the environmental impact. The consumption of raw materials in the industry is large and the quantity of waste is increasing. The energy consumption in both the construction industry and the housing sector is also heavy. Not only as regards to the heating of houses, but also as regards to the processes of manufacturing and transportation, through which the raw materials run in order for the industry to create bricks, steel and concrete for construction.**

The project contains a concrete assessment of aspects concerning resources and environment in connection with the recycled house. The assessments are compared with a conventional construction. The project also presents a method based on the life-cycle idea for the assessment of environmental aspects in connection with construction. The method includes the following aspects:

- Work environment
- Internal environment
- External environment

The project consists of a general report and six appendix reports. The general report contains a summary and conclusions, recommendations and a review of the results of the resource and the environmental assessments. The appendix reports are independent reportings of the different project activities.

- Appendix report 1: Description of method for resource and environmental assessment of the construction elements
- Appendix report 2: Comparison norm
- Appendix report 3: Registration of work environment
- Appendix report 4: Analysis of waste production and waste handling
- Appendix report 5: Energy analysis of the production
- Appendix report 6: Assessment of environment and work environment

The project concludes that

- In general, the recycled house possesses environmental advantages over the comparison norm
- It is verified that the significant differences lie in the extraction of raw materials and the production of construction elements
- There are no significant differences in the environmental relations in connection with operation and maintenance. This observation also applies to the internal environment.
- An improvement of the organisation, the design of this type of work place, and an elimination of the most physically demanding processes are important for a positive development of the recycling of building and construction waste.
- The completion of the project has provided a large number of concrete data on the construction's environmental problems.

Moreover, the project shows that recycling does not necessarily give environmental advantages, but that recycling can play an important role in connection with cleaner technology in the construction and that the integration of environmental aspects in the whole planning and completion of construction projects is crucial.

Concurrently with this project, the applied resource and environmental assessment method was tested and applied in similar projects. For instance the method was used in the EU project under the REWARD Programme “Development of a model optimising the reuse of building demolition waste and reducing the environmental impact of this waste” carried out in the period 1991-1994. The method was also used in connection with the project design of the international airport in Gardermoen north of Oslo, Norway.

The method’s suitability for evaluating the resource and environmental aspects in a construction process has been proved. Next step is to apply the method as an integrated part of the planning phase of new building under Danish conditions for the use of the project designer, to make him able to select materials from an environmentally friendly point of view. The assessment can also be adjusted or amplified so that it can be used for other environmental analyses in connection with construction.

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COWIconsult in co-operation with Laboratoriet for Bygningsmaterialer (The Laboratory for Construction Materials) and Danmarks Tekniske Universitet (The Technical University of Denmark), Institute for construction technique.

This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-9195

ISBN no. 87-7810-602-8

# The Recycled House– Cleaner Technology – Appendix Reports

## **Det genanvendte hus – renere teknologi**

### **Arbejdsrapporter – Bilagsrapporter nr. 35-40, 1996, Miljøstyrelsen**

**The present work reports are appendix reports to the work report “The Recycled House” – Cleaner Technology”. The aim of this project is to develop a method for environmental assessment of building projects in order to be able to estimate and compare a large number of environmental aspects of varying character.**

The project contains a concrete assessment of aspects concerning resources and environment in connection with “The Recycled House”. The assessments are compared with a conventional construction. The project also presents a method based on the life-cycle idea for the assessment of environmental aspects in connection with construction. The method includes the following aspects:

- Work environment
- Internal environment
- External environment

The project consists of a general report and six appendix reports. The general report contains a summary and conclusions, recommendations and a review of the results of the resource and environmental assessments. The appendix reports are independent reportings of the different project activities.

- Appendix report 1: Description of method for resource and environmental assessment of the construction elements
- Appendix report 2: Comparison norm
- Appendix report 3: Registration of work environment
- Appendix report 4: Analysis of waste production and waste handling
- Appendix report 5: Energy analysis of the production
- Appendix report 6: Assessment of environment and work environment

Appendix report 1 describes the method for comparing the assessment of construction materials used in “The Recycled House” and the conventional house. The method is designed for the concrete project, but can also be used as a paradigm for comparing resource and environmental assessments of construction projects in general.

Appendix report 2 contains an environmental audit of the demonstration project “The Recycled House”. The environmental audit is a comparative assessment, in which the reference is a conventional house with corresponding utility value. In the report, the aspects that separate “The Recycled House” from the conventional alternative are identified and described.

Appendix report 3 contains an assessment of the work environmental conditions in the phases: demolition, production and construction of “The Recycled House”. The assessment is only made where the work environment differs from conventional construction in connection with:

- Providing of secondary raw materials
- Production of building goods with recycled materials
- Construction in connection with building elements with recycled materials

The point of departure is taken in the method described in appendix report 1. Subsequently, in the light of the gained experience, the method has gradually been developed and adjusted.

The purpose of the analysis in appendix report 4 is to estimate how the waste production from “The Recycled House”, from a relative point of view, differs from the waste production of conventional new building. Simultaneously, an assessment of the size of the waste production is made. This is done because the processing of the recycled building materials compared to the production of new materials, in reality causes an extra waste production. In the construction of “The Recycled House” it is the first time that a comparison of waste production in new building with and without recycled materials is made.

In appendix report 5 the expected gross energy consumption in the construction of the house is analysed. The particular energy demanding conditions in connection with the production, use and disposal of materials for the “Recycled House” and the comparison norm are identified. The following elements are identified.

- Contribution to air emission
- Energy consuming processes of a building’s life cycle
- Waste
- Life cycle of the materials
- Energy analysis of the building elements

The aim of appendix report 6 is to estimate the environmental and work environmental consequences in “The Recycled House” seen from a life-cycle perspective. Against this background, a basis for comparison with a conventional building is made. The basis for the assessment of environmental and work environmental conditions is the selection of building elements and materials used in both the comparison norm and “The Recycled House”. For each building element an environmental and a work environmental assessment of the complete life cycle is made, that is, an assessment of the following phases:

- Extraction of raw materials
- Production
- Use
- Disposal and recycling

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COWIconsult in co-operation with Laboratoriet for Bygningsmaterialer (The Laboratory for Construction Materials) and Danmarks Tekniske Universitet (The Technical University of Denmark), Institute for construction technique.

This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-9195

ISBN no. 87-7810-602-8

# Environmental Review - Experiences from Green-House Centres and the Furniture Industry

## **Miljørevision – Erfaringer fra gartnerier og møbelindustrier Arbejdsrapport nr. 46, 1996, Miljøstyrelsen**

**The hypothesis of this project is that it should also be possible to introduce voluntary eco-management in small companies. This hypothesis was tested by introducing eco-management as an experiment in two production areas which are traditionally characterised by a large percentage of small and medium-sized companies: Green-house centres and the furniture industry. The purpose of the project was to develop and test the Eco-Management and Audit Scheme model (EMAS), which is specially designed for small- and medium-sized companies.**

EMAS is an environmental management system concerning the voluntary participation of industrial companies in a community scheme for eco-management and environmental auditing.

Environmental management, e.g. in the form of EMAS, is one of the answers to how companies can improve their environmental performance on an ongoing basis and thereby meet the increasing requirements of authorities, consumers, customers, sub-suppliers, etc.

The report deals with an environmental review of the company's environmental conditions, the preparation of an eco-management system that includes eco-policy, eco-objectives and eco-programmes. It also deals with internal environmental auditing - which is to be carried out by an environmental auditor - and the drawing up of environmental reviews, which should receive external confirmation. Finally, the report also deals with the assignments which the regulation places on environmental auditors and verifiers.

As a result of the project environmental auditing was introduced in seven different companies: Farstrup Møbler A/S og D.K. Plant, whose environmental statement exists as an appendix in the report, Carl Hansen og Søn A/S, EH Totalindretning A/S, Gartneriet Rosborg, Bellinge A/S, Gartneriet Thoruplund A/S and Ultra A/S.

The project has been significant in connection with the law on green accounts. The project's method of registering information on environmental data sheets has been applied by the Danish Environmental Agency in their preparation of the legislative work on the green accounts. Green accounts describe the companies' use of energy, water and raw materials as well as the character and the amounts of their use of contaminating substances.

Experience with the eco-management system indicates that it can be developed as an extension to the preparation of environmental programmes and objectives. The best procedure is to build up the management systems differently from company to company and in close co-operation with the companies in order to take maximum account of the wishes that a company may have to a management system.

Another experience to be drawn from the project is that the best way of creating an eco-management system is by designing it in a triad between the company, the environmental auditor and the verifier.

The benefits of the participating companies have been quite different, but it is generally agreed that it is possible to combine environmental improvements with economies.

Another result of the project is that environmental considerations have now become a more natural part of the company's way of thinking. Eco-management is an integrated part of the companies, in their organisation - strategically and financially in their sales and R&D work, in marketing and in their co-operation with the authorities. The employees are now involved in day-to-day environmental management.

Finally, the eco-management system has opened up for new marketing possibilities for the companies.

One of the aims of the project was to reach a complete description and understanding of how the method works so that the capacity, purifying capacity and other operational data could be stated for different operating areas. This goal was not fully reached.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0908-9195

ISBN no. 87-7810-627-3

# The American Waste Handling System

## Det amerikanske affaldssystem

### Arbejdsrapport nr. 49, 1996, Miljøstyrelsen

**In USA there is no tradition that public management and problem solving takes place in the supply area and it is therefore interesting to study how the waste handling system is organised in the USA. This report has a twofold purpose: It aims at studying how the environmental authorities can control the waste flow in a market-dominated waste handling system and at clarifying at which technological stage the American waste handling system is.**

The US produces a large quantity of waste. The average American produce approx. twice as much waste as the average Dane and the main part of the waste is deposited. Not until the nineties did they begin to give priority to the waste handling area in order to reduce the quantity of waste and increase the recycling of materials, since there is no political willingness or possibility to place environmental demands on the Federal States. However, where the local politicians and the public have a positive attitude, splendid results are seen in the recycling area.

In the US the waste handling system is privatised to a wide extent. The result of this is that the municipalities have little knowledge of the waste flow and lack political support to manage it. It is not possible to manage the waste with general rules and guidelines, because it is necessary to enter into an agreement with each single haulage contractor. The transportation between the states is therefore uncontrolled. As a result of this, the municipalities not only make sure they get the waste because they own a waste disposal plant – the waste will automatically end up where it is cheapest to dispose it of.

Against this background it is paradoxical that the authorities at different levels spend more time on making war on each other discussing which jurisdiction should be under which administrative level, instead of discussing, seen from an environmental point of view, what is better administered in the public and the private sector, respectively.

On the other hand, there are some examples of successful programmes carried out by the public sector. Especially programmes which aim at promoting the demand for recycling materials and at developing the market for recycling materials. In this connection it is relevant to mention the Recycling Market Development Zone in California, which is worth taking a closer look at both in Denmark and in Europe.

As for the enthusiastic part of the publication, there is generally a greater commitment to recycling in the USA than in Denmark. As a consequence of this, in the US, at all levels, they spend more money on information campaigns to change attitudes than in Denmark.

As regards to the technical level in the waste area, the US is not ahead of Europe or Denmark. Though, there are some plants and activities in the US, which could be a source of inspiration. An example is the waste disposal site technology because many places they use membrane systems, which outperform the Danish and the European when it comes to safety.



Also, when it comes to collection systems, the Americans are far more efficient than we are. This is due to the fact that the citizens in the USA can take the garbage to the road themselves instead of, as in Denmark, having it collected from their private ground.

As regards to the work environment the conditions in the USA are beneath contempt. One exception is the collection of waste in side-loader vehicles, which compared to the traditional Danish collecting system without carts, is a work environmentally better alternative.

Seen from a future perspective, it would be frightening if the American system with growing waste quantities, increased market dominance and smaller possibility of managing the waste flow became reality in Denmark.

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This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-9195

ISBN no. 87-7810-625-7

# Reduction of Water Consumption in Residences

## Vandbesparelse i boliger

### Arbejdsrapport nr. 51, 1996, Miljøstyrelsen

**This report evaluates the possibilities of reducing the water consumption in residences and what the consequences are for the existing drainage systems. This report should be considered a supplement to already existing guides concerning the reduction of water consumption in residences.**

In Denmark the water supply is based on ground water which is used for drinking water without extensive purification. During recent years the increased consciousness of the necessity of reducing the water consumption, if status quo shall be preserved, has produced numerous technical initiatives for water saving measures.

This development has been furthered not only by the environmental aspects, but also by the increased excises on water and drainage.

In the industries water-saving measures have been developed and implemented as a consequence of an increasing number of water consuming processes. Within the building industry campaigns have been carried through with the objective of informing the consumers of do-it-yourself measures to reduce the water consumption.

The campaigns have primarily been aimed at changing bad user habits and proposals for purchase and installation of simple water saving devices. Proper package solutions where savings are obtained without the awareness of the consumer and where the savings – such as reduced water flow incorporated in the design of water pipes and drainage pipes – are not yet available. Instructions for the design of systems where rainwater and “grey waste water” are recycled are also not available in a general, accepted form.

Chapter 2 of this report is about water savings in a general way and describes some of the possibilities of reducing the water consumption by means of relatively simple measures.

Chapter 3 is about the possibilities of designing water pipes so that the reduced water consumption results in smaller pipe dimensions and thus reduces the consumption of pipe materials.

Chapter 4 describes in detail the subject of water saving toilets. In private dwellings the toilet accounts for the largest water consumption and furthermore the flushing water from the toilet is important for the natural purification of the drainage system.

A reduction of the amount of flushing water means that special measures must be taken when the discharge system is designed. These measures are amplified in chapters 5 and 6.

Chapter 7 gives detailed instructions on the design and execution of drainage systems that have been approved for use together with water saving toilets. Chapter 8 describes an approved renovation system with smaller pipe dimensions than traditional systems. This is done by using toilets that flush with 3.5 l of water per flush.

Chapter 9 describes, by means of figures and text, a tool for assessing the condition of old drainage pipes. This method makes it possible to decide whether there is a risk of blocking water saving devices are installed in an existing drainage system.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0908-9195

ISBN no. 87-7810-640-0

# The Danish Consumption of PVC 1994/1995

## **Det danske PVC-forbrug 1994/1995**

### **Arbejdsrapport nr. 53, 1996, Miljøstyrelsen**

**This report is an update of the report “Follow-up on the Danish Consumption of PVC” (Opfølgning af det danske PVC-forbrug), which was carried out in 1990 by “the Danish Technological Institute” (Dansk Teknologisk Institut). On the background of information given by “the Central Statistical Office in Denmark” (Dansk Statistik) an analysis of PVC material flow, which covers 90% of the consumption of PVC during the last quarter of 1994 and the last three quarters of 1995, is worked out in this report.**

The Danish Environmental Protection Agency (Miljøstyrelsen) wishes to follow the development of the Danish consumption of PVC and this is the background of the report.

To make the calculations in the report, material from the Central Statistical Office in Denmark (Dansk Statistik) has been used. However, since it is the companies themselves, which pass on the information on e.g. goods, there is a risk of mis-registration at the Central Statistical Office in Denmark (Dansk Statistik). Restrictions and the risk of mis-registration regarding import and export have therefore been taken into account in the project.

Other conditions may give an incomplete picture of the extent of the flow of goods and in the report some of these have been considered and others not. It has been considered that some goods may be listed more than once but so called “hidden” import or export has not been taken into consideration and neither has e.g. import/export of packed goods.

In connection with the analysis of material flow, apart from the division of raw materials, semi-products and products, a division of Danish production, import and export along with soft and hard PVC has been made as well. The single elements have been examined and a comparison with the analysis of material flow from 1998 has been made. The numbers are illustrated.

A comparison of the material flow from 1994/5 with the material flow from 1988 shows that the supplied amount is more or less the same in these two periods. The amount of supplied soft PVC has declined with just under 20 % and the amount of supplied hard PVC has increased with circa 15 % in this period.

The report includes 21 figure appendices.

#### *Author/ institution*

DTI Miljøteknik has carried out the project on initiative taken by the National Agency of Environmental Protection in Denmark (Miljøstyrelsen)

This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195  
ISBN no. 87-7810-649-4

# Review of Environmental Fate and Effects of di(2-ethylhexyl)phthalate

## Redegørelse over DEHP's påvirkning af miljøet Arbejdsrapport nr. 54, 1996, Miljøstyrelsen

**Today there are many reports on the physical and chemical properties of DEHP. Nevertheless, due to experimental difficulties in connection with the investigation, the physical and chemical properties of this substance are still connected with some uncertainty. The present report is an attempt to provide a thorough review of the environmental fate and effects of DEHP.**

In general, DEHP, is considered not readily biodegradable. After acclimation of the micro-organisms, the substance degrades relatively fast. Due to the ubiquitous use of DEHP, the micro-organisms in many treatment plants are expected to be acclimated to degrade DEHP, and in some laboratory tests using micro-organisms from already exposed treatment plants, the substance is found to be readily biodegradable. However mass balances on treatment plants based on chemical analyses demonstrate that due to the strong sorption of DEHP to particulate matter, only a minor degradation can be expected in practice. Moreover, based on tests simulating the conditions in the aquatic environment is considerably lower than in treatment plants. Finally, no biodegradation is expected in anaerobic conditions.

The bioaccumulation of DEHP has been investigated in numerous studies with aquatic organisms from various taxonomic groups. Bioconcentration factors from 40 to more than 100000 have been determined and it is therefore concluded that DEHP is very bioaccumulative.

It must be concluded that no acute or chronic lethality is found at concentrations below or at the water solubility limit (0.05 mg/l). However alterations or affects are found at biochemical level at low concentrations (NOEC = 0.0037 mg/l). Moreover, in laboratory test systems it is possible to test DEHP in concentrations considerably higher than the water solubility limit, as the substance forms stable emulsions because it is a liquid with a density close to 1 g/ml. At these conditions, acute lethal effects are found in concentrations of a few mg/l. The results can, however, not be extrapolated to environmental conditions, as such emulsions cannot be expected to form or persist in nature. Thus, in the environment no acute toxic effects are expected.

It is recommended that DEHP be classified "R53: May cause long-term adverse effects in the aquatic environment" because of its general low biodegradability in tests for ready biodegradability, its low biodegradability in practice in wastewater treatment plants and in the aquatic environment, its high potential for bio-accumulation and its low water solubility.

However, as no practice has been established concerning the evaluation of toxic effects at concentrations above the water solubility limit in relation to environmental hazard classification, it is recommended that it should be discussed and decided how to interpret these data. If these toxicity data are taken into account, an environmental hazard classification with "N;R51/53: Toxic to aquatic organisms, and may cause long term adverse effects in the aquatic environment" could be assigned.

As demonstrated in the present review, there are still some areas in the effects assessment of DEHP that deserve a further evaluation. It is therefore recommended that the following topics be considered for further investigations or research:

- Alterations or effects at biochemical level. What are the reasons for these changes? They might be a result of the physical effects of the substance as e.g. the sorption to surfaces of the test species. What are the consequences of the changes on the organism, the population, or the ecosystem?
- Estrogenic effects. Some of the phthalates have been shown to exert estrogenic effects. It should be further investigated and evaluated, whether this is also the case for DEHP. If so, what are then the ecological consequences?

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-650-8

# Plant for Pre-Treatment of Refrigerators and Freezers from Households before Incineration

## **Plant for pre-treatment of Refrigerators and Freezers from Households before Incineration**

### **Arbejdsrapport nr. 55, 1996, Miljøstyrelsen**

**To remove refrigerating units most environmentally sound and in accordance with The Copenhagen Municipality Waste Programme a model with a central installation was prepared. This report includes a description of the project experimenting with treatment of refrigerating units according to the prepared model.**

In 1989 the Agency of Environmental Protection, City of Copenhagen prepared an action programme to limit derivation of CFC in the atmosphere. With a view to reach an environmentally sound handling of CFC when scrapping refrigerating units, one of the areas focused upon was collection of discarded refrigerating units from households. In the Copenhagen Municipality Waste Programme from October 1990 resolutions for the development of techniques for recycling or destruction of waste involving CFC, were included.

Collection of refrigerating units from households was initiated by establishing an arrangement at recycling stations, where the refrigerating units were tapped for CFC-12. Concurrently a treatment possibility was developed, which should not only include drawing from the coolant circuit but also destruction of CFC-11 in the insulation foam.

In April 1992 a work group consisting of representatives from I/S Amagerforbrænding, Renholdningsselskabet af 1898 and the Agency of Environmental Protection in the City of Copenhagen was set up to develop models for treatment of discarded refrigerating units. The work group went through the removal methods that existed at the time and examined three alternative models for removal. The result appears from the report of October 4 1993 made by the Agency of Environmental Protection, in the City of Copenhagen.

Model no. 1 described a way of treatment, which has been put into effect at the recycling plant Dansk CFC-Genvinding in Århus where the refrigerating unit is tapped for CFC-12. Then it is cut up in such a way that CFC-11 from the insulation foam can be rolled out and collected.

Model no. 2 includes a minor pre-treatment with removal of recycling and mercury parts. Afterwards the refrigerating units go to incineration without being cut up. In this way CFC-12 in the cooling system and CFC-11 in the insulation foam are destroyed.

Model no. 3 - the combination model - implies a more extensive treatment than model no. 1. All recycling parts, single parts and environmentally burdening parts are removed. Then the cabinet is cut up and sent to the incineration plant for incineration.

The work group recommended model no. 3 in respect of an environmental and recycling assessment.

The most essential reasons stressed were:



- All CFC from the coolant circuit and oil can be collected and CFC from the cooling system can be recycled.
- Recyclable parts can be separated, including metal, glass and plastic.
- Environmentally burdening fractions can be separated, including electrical components containing mercury and oil from compressors.
- Incineration tests in 1990 show a high level of destruction of CFC-11 in the insulation foam (99,9 %) and CFC-12 in the coolant circuit (98,4 %) respectively.
- Iron from the refrigerating units can be collected with the help of a magnet after incineration.
- The model is significantly better than other existing alternatives in The Copenhagen Municipality.
- With this in mind a plant for the tests to pre-treat refrigerating units from households was established

The established plant has proven the capability of the method as more than 6,000 units have been treated, which is equivalent to approximately 270 tonnes in the initial period of 8 months.

With an average content of 60 g CFC-12 and 220 g CFC -11 in a refrigerating unit, the total handling equals 360 kg CFC-12 and 1,320 kg CFC-11.

The treatment price per refrigerating unit has been calculated to DKr. 193 per piece in chapter 4.2. This calculation is based upon a careful estimate, which means that, other things being equal, this must be considered the maximum treatment price.

The greatest advantage of this method is the use of a simple technology, which does not demand large investments and at the same time gains the requested environmental result. Furthermore the plant has a flexible capacity which can be increased for market demands through automation and flexible working hours.

Because of the low investment demand a decentralisation of this type of treatment plant could be a solution in which transportation over long distances can be reduced.

Equally, a cleaner technology in connection with the production of refrigerating units will change the demands for treatment of discarded refrigerating units. Fulfilment of these demands is possible with this method because of the simple construction of the plant, which can be adjusted to the changed demands.

A basic condition for the described method is of course that additional incineration capacity is available on a modern refuse incineration plant.

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The report is subsidised by the Danish Department of the Environment's development programme for reduction of the CFC consumption.

ISSN no. 0908-9195  
ISBN no. 87-7810-655-9

# Plant for Pre-Treatment of Refrigerators and Freezers from Households before Incineration

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The report is subsidised by the Danish Department of the Environment's development programme for reduction of the CFC consumption.

ISSN no. 0908-9195  
ISBN no. 87-7810-655-9

# Pre-project on the Establishment of Denmark's first Ecological Hotel on Bornholm

## Forprojekt for etablering af Danmarks første økologiske hotel på Bornholm

### Arbejdsrapport nr. 57, 1996, Miljøstyrelsen

**This report describes the market possibilities, the economic possibilities and the conceptual sustainability in connection with the establishment of an ecological hotel in Svaneke on the Danish island Bornholm.**

Recently the years the hotel- and restaurant industry has experienced a worse financial and operational situation. The experience of establishing new hotels is that it may create problems to procure profitability to a given business - unless the concept of the overnight place is innovative.

In the light of the financial problems of the industry, the idea of an ecological hotel in Svaneke on Bornholm was considered realistic, especially because of a unique and innovative concept: The ecological hotel should offer a "green" holiday adventure. Therefore, it was planned to build the hotel as part of an environmental centre, which was intended to include several other facilities.

To avoid that the building of an ecological hotel should contribute only to an increase in the over-capacity already existing in the hotel industry of Bornholm, it was decided to initiate the plans of establishing an ecological hotel through a pre-project.

The pre-project was established on the basis of the following three phases:

- Phase 1: Market research. Drafting of operating and cash budgets. Drafting of a frame for an environmental account
- Phase 2: Temporary fundraising
- Phase 3: Invitation to architects to submit ideas. Holding of an architectural competition. Raising of funds to procure investors for plant, facilities, and possible initial operating of the hotel

Phase 1 was concluded early April 1996.

The subsequent success criteria were listed for the results of phase 1:

- The probability that an ecological hotel on Bornholm will attract new groups of guests to the island to such an extent that the hotel is secured a profitable operation must be proven.
- Even though the costs of construction to establish the ecological hotel most probably will be paid mainly by national funds, pension houses etc, the hotel shall not operate on a basis that distorts competition. Thus, the ecological hotel must, with regards to standard, correspond to a first-class hotel and differentiate from the other hotels of the island through a higher standard and a correspondingly higher price. Furthermore, the operation must be based on ordinary commercial terms.

The pre-project should thus form the guarantee for the ecological hotel as a financially, environmentally and socially acceptable business.

Today, nearly no experiments are conducted among the enterprises within the hotel and restaurant industry to investigate resource consumption (water and energy). Therefore, it was the intention that the ecological hotel should serve as an illustration project from which working results should be accessible to all interested parties in the tourism industry. In connection with the introduction of green taxes as of January 1, 1996 for trade and industry, the project acquired even more topicality and significance for the industry.

Investigations of the market potential of the ecological hotel as either a family hotel or a seminar and conference hotel have been conducted. A survey among German families with children indicates that the children-families might be concerned about the environment but not to such a degree that ecology at present is an important factor in connection with their choice of holiday-overnight stays. A survey among Danish, Swedish and German seminar and conference organisers revealed that the idea of an ecological hotel is considered interesting, but that the location on Bornholm does not meet the needs and requirements of the guests such as a central location and a low-priced product.

Each year, the Danish Tourist Board carries out screening analyses of seven European holiday travelling markets to expose the holiday motives of the populations. When looking into the results from the Swedish and German holiday markets, it proved impossible to point out any special interest in environmental considerations when planning a holiday. Neither was it possible to segment each single market to identify one or more target groups with greater concern for the environment than that of an average holidaymaker. If the results of the different market investigations are compared, it must be concluded that the existing material presents no possibility that an ecological hotel on Bornholm will be able to attract new segments to the island so as to secure the hotel a profitable operation.

The operation and cash budgets for the ecological hotel on Bornholm are based on the concept of two target groups which, during the survey, turned out to be non-existing. Thus, the budgets must be regarded to include great unreliability. This is also the case in the budget results, which from the offset were calculated at a very low yield on the capital invested in the hotel. Therefore, the necessity of a profitable business cannot be said to be plausible.

The frames of an environmental account for the ecological hotel are estimated to form a fine basis for the Danish hotel industry's further work with the way in which the environmental problems present itself.

From an overall point of view, the results of phase 1 of the pre-project could not demonstrate the likelihood that an ecological hotel on Bornholm could offer a profitable operation. According to the grounds of the pre-project it was therefore suggested to "Miljøstyrelsen" (The Danish Environmental Protection Agency) that the pre-project should be stopped after the presentation of the report on phase 1.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-657-5

# Environment and Economy on an Industrial Level

## Miljø og økonomi på brancheniveau Arbejdsrapport nr. 58, 1996, Miljøstyrelsen

**This report describes a number of interdisciplinary economic terms related to the environment. The use of this method should be seen as one of several tools to prioritise environmental improvements. The description and pricing of environmental issues should not stand alone in the prioritisation but should be included in the overall consideration with other significant aspects before a final weighing of the enterprise. The use of these terms is illustrated for selected industries.**

The purpose of describing and relating environment and economics to each other on an industry level is:

- To suggest, from calculations of the socio-economic effects, which priority to give to different aspects of the environmental efforts between industries and within each industry;
- To facilitate the estimation of how each industry contributes to environmental costs and how it will be affected by green taxes etc.

The descriptions of environment, working environment and economics are based on figures from 1991. It is therefore possible that the industries have undergone some changes. The report contains information about environment, work environment and economics in the following industries:

- Slaughterhouses
- Foundries
- Freight transportation
- Wholesale business
- Retailing

The report contains a definition and a description of the following terms: external costs, reduction costs and production costs.

The most important aspects of environmental politics, including discharge of CO<sub>2</sub>, SO<sub>2</sub> and NO<sub>x</sub>, water consumption/waste water, solid waste, working environment and hazardous substances, have been studied in relation to the selected industries. Furthermore, for each industry a scenario has been set up describing the economic and environmental consequences of existing and future taxes, bans, etc.

Finally, for each of the selected industries, the report contains "industry profiles" of economic aspects related to the environment which provide a comprehensive description of environment and working environment conditions within each industry plus an estimate of the socio-economic effects hereof. The industry descriptions are based on easily accessible data and information and in some cases on interviews with relevant persons.

It is the main conclusion of this project that the present work dealing with relations between environment, work environment and socio-economy at the level of the industry is meaningful as it facilitates the establishment of a comprehensive picture that can be useful

in several connections. Among other things, the methodology can be used by industries and environmental authorities as a tool for establishing a common basis for industry level agreements.

It is, however, also concluded that some problems in relation to pricing the environment still exist and the methodology used to estimate external costs is uncertain. However, one should see the development of the methodology as an iterative process. The use of this methodology creates an overview that can be used to identify areas where more knowledge is needed.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0908-9195

ISBN no. 87-7810-664-8

# Conversion to Organic Food Consumption in the Public Sector

## Omlægning til økologisk fødevarerforbrug i det offentlige Arbejdsrapport nr. 60, 1996, Miljøstyrelsen

**The purchasing policy of the state must be altered so that it also includes organic food. This report examines the possibilities of developing an organic, self-supporting and sustainable food system, in which the conversion to consumption of organic food in the public sector is performed in close co-operation with users, institutions, public administrations and producers.**

Politicians, staff etc. are more concerned about serving organic food in public institutions. This includes state, county and municipal institutions (e.g. prisons, hospitals, kindergartens and old people's homes).

Based on three years experience with the development of a strategy for transition to organic food for children in 25 kindergartens in Copenhagen it was proposed to develop and test a general model for conversion of public institutions managed by municipalities.

The model is based on the assumptions that organic food is a part of a greater phenomena including people's desire to act according to the ideas of the UN Agenda 21 and the ecological sustainability. Another assumption is that food is more than just nourishment, it is also the ecological awareness and skills belonging to the context of the food.

This implies that the model should include:

- Ways and means of learning about food and recycling both as professionals and as a main issue in the children (and adult care).
- Professional and informal systems, which can produce and distribute organic food in a local food web page.
- New ways and means of co-operation between the private and the public domains.

Following discussions with the Minister of the Environment, Svend Auken, it was decided to include the idea and initiate a project within the frame of the development of the green state policy for public procurements.

As this conversion concept is rather comprehensive it was agreed to carry out a pilot project in order to plan the main project. The project was carried out with funding from the Ministry of the Environment and Energy. The Ministry of Agriculture and Fisheries participated in the project board as they were also expected to fund the main project within the State scheme for support for the development of organic agriculture.

Two municipalities, Albertslund and Fredericia, respectively, joined the project. Both municipalities had already decided to convert the food consumption in their public institutions into organic food. Descriptions and analysis of existing policies, conditions and resources were carried out.

Based on the individual municipal situation strategies for the conversion process were developed in co-operation with each municipality. These strategies followed the ideas of the proposed model and included plans within each municipality for production and



distribution of organic food, change of kitchen routines and food schemes, establishment of management bodies and staff training.

A proposal for a project with a time frame of three years was drafted. The overall idea was to develop and improve the conversion approach by a process of reciprocal participation between the municipal groups and the project group and to manage, analyse and inform about the project and its elements to other interested institutions as well as politicians and municipal authorities.

Finally, the idea and the proposed budget were negotiated with the representatives from the two ministers. The proposed plans for the conversion turned out to include too many aspects according to the civil servants. The implication was that the total budget would be too high. However, the project group argued that this project must be complex and include several parallel aspects, and therefore it would be managed and funded separately. The project group argued that this would prevent the flexibility of the conversion process needed in order to meet the local demands.

The project group decided therefore not to continue to apply for funding for the main project. The far-reaching and locally based ideas of this conversion concept seems to be in opposition to the dominant views on both the current municipal and state economics. In spite of this, it is the notion of the project group that our concept is a logical consequence of the Agenda 21 approach if major problems in the future with e.g. energy, employment, water, food, etc. are to be avoided.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0908-9195

ISBN no. 87-7810-671-0

# Washable Textiles for Men's Suits

## Vaskbare tekstiler til habitter

### Arbejdsrapport nr. 64, 1996, Miljøstyrelsen

**The objective of the project has been to establish guidelines for construction and manufacturing of complicated garments such as men's suits and outer garments which enables maintenance by means of washing in water. The reason for this is to reduce the use of chemicals used in dry-cleaning and to make it possible for the customer to clean the clothes themselves.**

During the initial meetings and after the tests of the first pilot products (suits) it was decided to concentrate on men's jackets produced of wool and wool blends, as problems with water washing of trousers seemed to be less than, or the same, as for the jackets.

It was decided, that the clothing manufacturer Falbe-Hansen Konfektion A/S (FHK) should contact all their present suppliers and ask them to supply water washable materials, which were to be included in the first initial tests with washable jackets.

DTI Clothing and Textile (CT) were at the same time to contact institutes, companies etc., which were supposed to be active and have experience within this field, with the aim of comparing their results with FHK's pilot production of jackets.

Four types of textiles were chosen and their fabrication and weight were examined. The jackets were washed 10 times each after two kinds of washing which were domestic washing and wet cleaning.

The project has proven, that it is possible to construct and produce a washable jacket not only of 100% polyester, but with an outer fabric of wool/polyester, interlinings of polyester/viscose, lining of triacetate/nylon and collar felt of 100% polyester. The main reasons why it has been possible to produce a washable jacket are that specifications were fixed and thorough tests of the used materials were carried out.

It has not been necessary to change the construction of the jackets. All seams, placing of interlinings etc. have been retained. The choice of material and construction has proven conclusive.

The manufacture of the jackets was the same as with an ordinary jacket. It has not been necessary to reinforce the seams etc.

From the beginning it showed that in the case of pure wool and wet treatment the interlining and the wool behaved differently whereby the interlining came loose.

In the blended fabric wool/polyester tests showed that some constructions could work together, for example with a shrinkage of  $\pm 1$  %.

Agents and producers of interlining have received the project description and have also shown new developments, but problems are not yet solved satisfactorily. (Same selection in washable and non-washable products).

Regarding producers of outer fabric it must be assumed, that the demand for more washable products will grow and that they will enlarge the effort in this area.

Lining producers do not consider this market as attractive yet, why the development is minimal.

Producers of collar felt do not develop washable products.

Looking closer at the washing results it appears that outer fabric of 100% wool is not suited for water washing, but blending with polyester improves the results considerably. This characteristic of blending polyester with other fibres can be seen for lining, interlining and collar felts as well.

Analysing the importance of yarn count it seems that same yarn count in length and width has a positive influence on the washing results. The setting of the fabric and the elasticity of the construction does not seem to have any influence.

By choosing washing method, either domestic washing or wet cleaning, tumble-drying should be avoided, because the fine and loose fabrics such as linings, interlinings and collar felts are influenced.

The biggest problem of the project was to find suitable washable interlinings. Apart from this the full-scale tests showed that the attachability of the interlinings with repeated washings was fluctuating.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-623-0

# Spreading of Sewage Waste

## Spredning af spildevandsslam

### Arbejdsrapport nr. 65, 1996, Miljøstyrelsen

**The use of local authority sewage waste on agricultural areas has been debated during the recent years. The discussion has focused on the contents of undesirable substances in sewage waste in the agricultural production and on the possibilities of spreading the sewage waste. Apart from that it has been discussed whether the sewage waste could be equalised with the fertilisers which are normally used in the agricultural sector.**

**This project was conducted with the object of studying the possibilities of spreading local authority sewage waste when applying different types of sludge and different spreading techniques.**

The tests included studies of the distribution along and across the direction of motion of four representative types of sludge and ten different spreaders of different makes and principles of construction.

The sludge types were selected according to dry matter content and drainage methods. The dry matter content varied from 16 to 30 %. The drainage methods consisted of centrifuging and pressing by means of a flat-belt separator or a plate filterpress.

The distribution along the direction of motion was determined for stationary arrangements where the decreasing spreader and sludge weights were registered every 10 seconds in order to clarify the general emptying process. The distribution across the direction of motion was determined by spreading the sludge over 0.50 x 0.50 m areas at a total width of 28 m. The spreading area was covered eight times, so that the recorded spreading pattern would correspond to the average spreading pattern of the entire load. For both studies the desired rate of application was 20 t/ha at a working width of 12 m and at a travelling speed of 5 km/h.

The coefficients of variation were calculated in both tests, and the findings were used as a criterion for the accomplished work. Coefficients of variation less than 15 % are considered to be satisfactory on equal terms with the demands made on the spreading of farmyard manure and mineral fertiliser.

The results of the tests prove that, in general, the distribution along the direction of motion is poor, however strongly dependent on the quality of sludge in question. It was seen that for all combinations of spreaders and sludge types with a dry matter content less than 20 %, the rate of application generally tended to decrease during the process of emptying. In the beginning of the process the rate of application was from 100 to 200 % of the average, whereas towards the end it was only 50%. The differences were smaller for sludge types with a high dry matter content, but here the rate of application may be affected by cloggings (bridgings), resulting in a very irregular emptying process.

After an alteration of the equipment, the average distribution across the direction of motion proved satisfactory, and an acceptable working width could be attained. At the beginning of the tests light-fluid sludge would leak from the machines unintentionally, which would affect the pattern of distribution unfavourably.

The tests showed that the primary factor influencing the distribution of sewage sludge was the sludge quality, and that there is a general need to upgrade the sludge to products with a

minimum dry matter content of 25 % and a homogenous structure which will permit an even rate of application.

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This report is subsidised by the National Council for Recycling and Cleaner Production

ISSN no. 0908-9195

ISBN no. 87-7810-688-5

# Employee Participation in the Implementation of Cleaner Technology in the Co-Operative Slaughter-house TICAN

## **Medarbejderdeltagelse ved indførelsen af renere teknologi på Andelsslagteriet TICAN**

### **Arbejdsrapport nr. 66, 1996, Miljøstyrelsen**

**This company report for the co-operative slaughterhouse TICAN has been written in the light of the company's participation in the MIRT-project (Employee Participation in the Implementation of Cleaner Technology) in the period from spring 1993 until autumn 1995. The report describes and analyses the course of the project in the company. Furthermore it suggests how employee participation and the environmental effort in the company could be continued, among other things by means of the environmental management system.**

Throughout the project period TICAN took initiatives which increased the original content of the MIRT-project. Examples are implementation of the integrated quality and environmental management system and especially the constellation of nine divisional environmental groups.

The groups have worked with environmental reviews, drawing up targets and action plans and initiated activities with regards to solving of problems related to health and safety as well as environmental problems. Through the project the employees now have an overview over the principles of pollution prevention and cleaner technologies and thereby a new basis for future environmental efforts.

Since 1985 TICAN has been aware of environmental conditions originally due to increasing prices of wastewater and thus related to internal resource savings and minimisation of production costs. In general, TICAN acted according to regulatory demands and thus reactively. By means of the trade consultancy for cleaner technology, participation in the MIRT-project, and not least implementation of a certified quality and environmental management system, the company has changed to a preventive strategy which at the same time includes a more systematic effort than before.

TICAN is a non-hierarchical organisation where communication, co-operation and co-ordination in the company still to a large extent is informal with "a short distance from word to action". In general TICAN has an extensive employee participation in problem solving and in decision-making processes, especially in comparison with other companies in the slaughterhouse trade.

The existing company culture, management and organisational structures and the company's tradition with employee participation and ongoing environmental improvements have been good preconditions for the project. However, the company's preconditions have also been an obstacle for the groups' environmental effort. Focus on production, lacking recognition of the importance of change processes, and some of the environmental groups' lack of dynamics have especially appeared as barriers to the project's intentions.

Through the environmental effort TIKAN has achieved a number of specific improvements regarding technical optimisation. Whether TIKAN has advanced employee participation, seen in the light of the company's traditions, is questionable. Mainly well-known and deeply rooted methods have been used in order to involve the employees. Nevertheless the nine divisional groups were an extension of the existing traditions of decentralisation.

Furthermore the introduction of a integrated quality and environmental management system certified according to ISO 9002 and BS 7750 has contributed to an alteration of the company's preconditions towards a more systematic effort. The system will consequently be a factor in securing that the environmental effort is continued, and that the process of increasing the employees' environmental awareness is sustained.

The report provides the following recommendations for continuous improvements of the environmental performance as well as the participation of the employees:

- Improvement of the dynamics in the decentral environmental work through a reorganisation.
- Increase the employees' motivation through e.g. courses for the divisions or external introductions.
- Maintenance of the systematic and process orientated work in groups e.g. via formulation of a 'business plans'.
- A co-ordination and planning group which takes independent initiatives.
- Longer periods of planning in the environmental area with long-term objectives in line with the environmental policy.
- Enhancement of environmental information and development of an environmental database.
- Use of formalised company networks and bench marking.
- Continued improvements of the management system by strengthening the dynamic and the systematic efforts.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0908-9195

ISBN no. 87-7810-690-7

# Employee Participation in the Implementation of Cleaner Technology in HL-filet, Hanstholm

## **Medarbejderdeltagelse ved indførelsen af renere teknologi på HL-filet, Hanstholm**

### **Arbejdsrapport nr. 67, 1996, Miljøstyrelsen**

**HL-filet Hanstholm has undergone an experimental project, which aims at studying the possibilities of involving the employees in the process of introducing cleaner technology in the fishing industry. The present report describes and analyses the project and gives recommendations to how the future work in this field should be carried out. The report is also aimed at other industries that take interest in the matter.**

This company report for the fishing industry has been written in the light of the company's participation in the MIRT-project (Employee Participation in the Implementation of Cleaner Technology) in the period from the spring of 1993 to the summer of 1995.

A number of exciting development projects have been carried out at HL-filet, for instance extensive employee participation in the form of a questionnaire study and group discussions. In co-operation HL-filet and the environmental group have specifically implemented: the appointment of a responsible environmental group, the implementation of an environmental review, the setting up of objectives, enquiries about possible solutions and the preparation of an action plan.

During the project period the environmental aspect has been put on the agenda in the company and both employees and management have achieved an increased awareness of external environmental aspects in relation to the production of the company. In particular the participants of the environmental group have gained substantial insight in the environmental relations of the company. In this way a process has begun in which the external environment will continuously be in focus, and where the greater part of the suggestions of the employees for the action plan has either been implemented or is being implemented. The introduction of production meetings with the participation of key employees, the transference of the environmental work to the safety council and a more regular meeting structure in relation to the safety council and, in addition, the joint council have strengthened the formal employee participation in the company.

At the start of the project the company had not previously worked systematically with external environmental conditions, and so far this field has had low priority in the company. Also HL-filet had no traditions for extensive employee participation, and primarily shop stewards and safety representatives had great expectations of the project. So far the company had typically acted reactively against the pressure from external partners and had initially remained reluctant to the implementation of activities. Primarily three demands are, and have been, determining in relation to the initiatives of the company: The requirements of the environmental authorities that waste water is treated, the requirements of the Factories Inspectorate about an action plan regarding monotonous repetitive work and also the customers' demands for quality.

The participation in the MIRT-project and the project "Start Prevention" has indicated that HL-filet is establishing a more preventive and proactive effort. Yet there has been a



dilemma between the good intentions of the management and then the actual implementation, where the considerations for the daily production at HL-filet have often resulted in the fact that the intentions have not been followed up sufficiently. The existing culture of the company, the structures of management and organisation and the tradition of co-operation at HL-filet have played a prominent part in the project. To a great extent these conditions have been favourable and have been the foundation that made it possible to implement unusual developmental initiatives for the fish-processing industry in many respects. However, the conditions of the company have also caused problems and acted as a barrier to how far the company has reached with the environmental efforts initially. Specifically, for instance the horizontal organisation and the informal style of management of the production manager have been a positive influence, whereas the tradition of focusing on production and limited resources of management has been a barrier in the course of the project.

HL-filet is in many ways a typical fish-processing industry with the conditions of organisation, management, work, and environment connected to a small and fast growing company. In general, compared to other fish-processing industries of the area the company has a relative good working environment and for instance less sickness absence.

There is informal co-operation between the management and the employees in the company, which has made it possible that the employees have production responsibility and indirect influence on decisions and also a loyal relationship to the production manager. The employees regard HL-filet as one of the best fish processing industries of the area.

The horizontal organisation of the company supports the informal co-operation, but it also increases the limited systematism in for instance the planning process. Long-term planning has certainly not been part of the present traditions of the company.

The report contains the following recommendations regarding the future efforts at HL-filet concerning environment, work conditions and employee participation:

- A change in the division of labour with a more extensive delegation to the employees and thus a redefinition of the tasks of the management
- The use of the knowledge of the environmental group in preventive work
- Active use of the safety council and the joint council as the formal forum of dialogue between employees and management
- The definition of the course for further preventive efforts
- Follow-up of the action plan
- A continuous and systematic effort

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-691-5

# Increased Recycling of Water in the Paper Industry

## Øget genbrug af vand i papirindustrien

### Arbejdsrapport nr. 68, 1996, Miljøstyrelsen

**The paper mills are among the industries with the largest water consumption, and therefore many plants have started to recycle the water, which can cause problems with the work environment and obnoxious smells. The purpose of the project has been to develop a technology to control the microbial growth in re-circulated water used in the paper- and cardboard making industries, and in that way, to solve the problems in the work environment and the bad smells caused by recycling of the water and if possible to achieve completely closed systems.**

The project has been carried out in co-operation with Brdr. Hartmann A/S, IPU (Institute for Product Development) and VKI (The Water Quality Institute).

In chapter 2 the production of cast cardboard at Brdr. Hartmann A/S is described. In short terms it consists of three steps:

- Dissolution of recycled newspapers
- Steeping of the product in paper-making machines
- Drying of the product

In chapter 3 the water system is described with the ordinary water consumption in the production as opposed to the optimal water consumption by using the measures introduced today. Thereby it will be possible to see how a targeted effort will be able to reduce the ordinary water consumption remarkably.

Chapter 4 describes the mechanisms used for a reduction of the microbiological activity in the water- and production systems at Brdr. Hartmann's. Different tests are described e.g. tests with biofiltration and membrane filtration, and an account of the different results and conclusions regarding this is given in the chapter.

Chapter 5 describes three possible scenarios for increased recycling of water. They are expected to result in a controllable biological growth with the possibility of reducing the use of biocides and water.

In chapter 6 an environmental valuation of the contents in wastepaper and the used raw materials and chemicals are made. Furthermore, a statement has been made for the mass-streams for the contents in waste paper and chemicals, which however is mostly based on estimations.

In chapter 7 the three scenarios are environmentally valued in accordance with the LCA-method. Thereby it appears that it is a reduction of the usage of biocide alone, which can defend further water purification and recycling at Brdr. Hartmann's. In return it will be beneficial to introduce water-purifying technologies, which will be able to reduce the use of biocides.

Chapter 8 concludes that biofiltration is a suitable technology to control the microbial growth in the re-circulated water used in the paper- and cardboard making industry and that ultrafiltration of the re-circulated water produces water of a high quality. Furthermore, it

can be concluded that any reduction in the use of biocides will, all in all, lead to an improvement of the environment. To document the reductions in the use of biocides it is recommended to test the upgrading techniques used in a production-like scale. Apart from this, other suggestions are made for the use of the various filters.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-693-1

# Woodshot – Development of Lead-Free Shot for Hunting

## Woodshot

### Arbejdsrapport nr. 77, 1996, Miljøstyrelsen

**The use of lead shot for hunting has been prohibited in Denmark since April 1993. Hunts in woodland using lead shot obtained a dispensation to continue using lead shot until April 1996, so that a type of shot could be developed which, in the same manner as lead, would not cause damage to the processing machines used by the forestry industry. Examinations as far back as 1985 indicated that steel shot damages the processing machines used by the forestry industry.**

In April 1994, a steering committee and a working group were set up. The members of these groups are indicated under point 1.0. The Danish Environmental protection Agency granted the sum of DKK 2.11 million for completion of the project entitled "WOODSHOT". The project was completed on the 1st of January 1996.

In this project, a number of specifications were set up for shot which now can form the basis for future qualification requirements for shot.

Quality requirements for shot for hunting in woodland can be divided into four categories:

- A. The environment
  - A1. The outer environment
  - A2. Food (poison, smell, taste)
  - A3. Animals (sickness, poisoning)
  - A4. Animals (does not splinter)
- B. Hunting and hunters
  - B 1. Ballistics
  - B2. Form stability
  - B3. Specific gravity
  - B4. Damage to gun barrel
  - B5. Price
  - B6. Strategically sensitive material
- C. Value and properties of the timber
  - C1. Veneering properties
  - C2. Discoloration
- D. Fabrication
  - D 1. Work environment
  - D2. Production technique
  - D3. Storage problems

The types of shot examined during the project can be divided into three groups:

- Metallic
- Plastic-bound metal particles
- Chemical-bound metal particles

In the course of this project, approximately 17 usable types of shot were developed, within the three material groups. Amongst these 17 combinations, the steering committee and the working group selected three types, on which further work has been carried out.

An environmental evaluation has been carried out on the selected types of shot, and these were found to be satisfactory. The fabrication technique has been thoroughly tested and likewise found to be satisfactory, and this is also the case with the work environment.

A veneering test and a processing test have been carried out in a fast outer, and all the types of shot were approved.

The various types of shot have been approved during individual shooting experiments into a gel, in which shoulder plaids from pigs were imbedded (the gel has the same consistency as muscle texture). None of the shot splintered.

Form stability, ballistics and damage to the gun barrel have been tested and found to be satisfactory.

The price has been accepted by the steering committee as being suitable.

Finally, two hunts took place (ducks and pheasants, respectively) in order to test the cartridges under practical conditions. These showed that one of the shot types was acceptable in its present form, but further refining of the shot and cartridge is recommended.

In addition one more of the three selected types would appear to be promising after further development.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0908-9195

ISBN no. 87-7810-714-8

# Employee Participation in the Implementation of Cleaner Technology at Kompan A/S

## **Medarbejderdeltagelse ved indførelse af renere teknologi på Kompan A/S**

### **Arbejdsrapport nr. 78, 1996, Miljøstyrelsen**

**This company report for Kompan A/S has been written in the light of the company's participation in the MIRT project (Employee Participation in the Implementation of Cleaner Technology) in which five companies took part. The general aim of the MIRT project was to document the employees' resources in the implementation of environmental management. One of the participating companies was Kompan A/S. For Kompan A/S the MIRT project was part of a larger project, whose aim was a certified environmental management system according to British Standard 7750. The present report describes and analyses the course of the project at Kompan A/S.**

Through many years Kompan A/S had been working on creating a high and strong profile as regards to environmental issues. As an example, new employees were employed at the end of the eighties to make life-cycle assessment for the products. The company's use of resources and consumption of environmentally dangerous substances and materials were minimised, and a waste sorting system was established. In 1992 the company decided to expand its certified quality management system (ISO 9002) to an integrated system for management of quality, environment and work environment. This task was initiated in the summer of 1993, when Kompan A/S joined the MIRT project.

Kompan A/S is a company with almost ideal conditions for employee participation in the preventive environmental work. The company had a culture which was based on and improved the employee participation, a management which felt obliged to make preventive environmental efforts and to involve employees in the planning, and well-educated employees, who were committed to their company and motivated to participate in the environmental work.

In general, the employees found it natural to have environmental management. They did not fear that it would result in a loss of jobs, as the company was considered to be at the leading edge of environmental issues. Instead the employees expected that the environmental efforts would help to ensure the survival of Kompan A/S in the long term.

As a consequence of the company's traditions, both the management and the employees felt, from the beginning, that it was only natural to involve the employees in the environmental work. Accordingly, the preventive environmental work was started in a way that completely lived up to the expectations, which were expected of a company with so sound conditions.

The preventive environmental efforts were organised by a safety committee and an environmental committee that acted as the co-ordination group with reference to for the purpose established environmental management committee at management level. The management declared that 2000 man-hours had been dedicated to the employee participation in the implementation of the environmental management system. All employees were informed that the company had decided to implement environmental management and that all employees were to participate. All employees gave their

viewpoints on problems and solutions and they were involved in the initial mapping out of the situation.

Later on, all employees were sent on a two-day environment course and 20 cross-organisational environmental groups, which represented all groups at Kompan, were established. Subsequently, these groups solved a number of problems in connection with the environmental management system.

There is no doubt that the employees have played an important role in the company's implementation of the environmental management system. More specifically, they have contributed with "hard facts" about the company's environmental and work environmental conditions and have given suggestions to a general environmental policy, to procedures to "The Guide to Environmental Management", and to how to reduce the requirements of materials, etc.

However, perhaps the employees' most important contribution is not to be found at this concrete level, but rather in their role in the process, which was launched by the company's great commitment to employee participation. The employee participation has ensured the efforts a dynamism, which supported the environment project when other competing projects claimed resources and management capacity. Subsequently, such an effort, other things being equal, will probably mean that the employees will contribute to using, maintaining and further developing the environmental management system in a more constructive and active way than they would have done, if the dedication to employee participation had been smaller.

On the other hand, the process of employee participation in the implementation of environmental management at Kompan A/S was not trouble-free. Some of the cross-organisational environmental groups could have functioned better if they had been prepared for the fact that such an organisational change requires a certain attention and if they had been more aware of the problems of making some of the groups function properly. Moreover, some of the employees experienced that the competition between the different projects in the company caused a certain doubt about the resources that were dedicated to the employee participation in the environmental work. Finally, some incidents, which had nothing to do with the environmental project, had a negative influence on the employees' motivation to perform an active environmental role.

The changes and their effects contributed to making the implementation of the environmental management system more slow. But in March 1996 Kompan A/S could announce to the public that Dansk Standard (Danish Standard) had approved the environmental management system of Kompan and that the company had been granted a certificate, which guarantees that the system is in accordance with the British Standard 7750.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195

ISBN no. 87-7810-715-6

# Further Development of Water Dilutable Textile Print Colours for Cool Flash Printing

## Videreudvikling af vandfortyndbare tekstiltrykfarver til Cool Flash trykning

### Arbejdsrapport nr. 79, 1996, Miljøstyrelsen

The report consists of a description of ordinary piece-print on textiles and the Cool Flash technique. The aim of the project was to; describe the print technique with regards to piece printing of textiles; to improving the already existing water dilutable textile colours; and to carry out an evaluation of the existing environmental impacts by comparing traditional textile printing with the new “Cool Flash” technique. This includes an evaluation of the print colour’s primary life cycle from production to waste.

As a part of the project the procedure of manufacturing piece-print with serigraphy is described, including how traditional water dilutable printing differs from Cool Flash printing. Besides the actual manufacturing process, different types of print colour – including water dilutables and plastisols and their hardening conditions – are described.

In the course of the project different guidelines for Cool Flash colours that differ from ordinary water dilutable colours by having a freeze temperature of between -10°C and +5°C, are given.

The developed freeze colours are estimated to have some technical properties that roughly correspond to the commercial products that have been examined. These include reology, elasticity, dry rub sustainability and wash ability. The wet rub sustainability is though just below what is acceptable. This property can be improved via optimisation and choice of cross-links that increases the cross binding at the binders.

The environmental impact of printing with water dilutable print colours, Cool flash colours and plastisol colours is described based on three company tests.

The work has proven that there are pros and cons with all the different ways of printing. The advantage with the plastisol colours is the relatively low consumption of energy, and that there is no water usage.

The advantage with the Cool Flash method is the low energy usage and the improved work environment during the process where there are no side effects due to heat and no de-steaming during the middle fixation. The disadvantage is the large waste of colour per functional unit in comparison with plastisol.

Some of the ingredients in water dilutable print colour can cause problems in the work environment and others in the environment. Another disadvantage is that the rinsed colour residual from the cleaning of the frames ends in the sewage system, which often ends as sludge in the wastewater treatment works.



PVC softened with phthalates is not a relevant alternative to water dilutable colours. The phthalates cause problems primarily in the work environment and the PVC because of the difficulty with waste disposing it.

The alternative print colour developed in the project contains polyurethane, which is a very elastic binder, which means it resembles plastisol print. Due to the manufacturing process, the polyurethane cannot be recommended because of the impact on the work environment. There might also be work environment problems in the usage phase.

Finally, it is warned against using spray glue to fix the textiles since aerosol creation is a problem for the work environment.

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This report is subsidised by the National Council for Recycling and Cleaner Technology

ISSN no. 0908-9195  
ISBN no. 87-7810-686-9

# Automatic Systems for Row-Specific Weed Control

## **Automatisk præcisionsstyring i ukrudtsbekæmpelsen Arbejdsrapport nr. 80, 1996, Miljøstyrelsen**

**This report describes the possibilities of using automatic systems for row-specific weed control in order to minimise herbicide usage in field crops. The main emphasis is in row crops, but also cereals are considered. Automatic guidance systems can facilitate mechanical weed control by narrowing the uncultivated area near the crop rows. With the current practice almost 40% of the total area remains uncultivated in row crops with 50 centimetres row spacing. Precision automatic guidance can decrease this area to less than 20% of the total area.**

The report consists of four main sections. In section one the prospects and limitations of various mechanical weed-control methods and band spraying are reviewed. In section two various principles of positioning field machinery are described. In section three the financial feasibility of mechanical weed control in beets together with band spraying is assessed and compared with conventional spraying. The last section includes a general discussion of factors that are important for farmers if they are going to adopt mechanical weed control supported by automatic guidance systems. The discussion is mainly focused on weed crops.

The available information on automatic guidance systems is mainly based on Swedish research and experiences, but also in the Netherlands and England technical research on guidance systems is currently being carried out.

Tractor hoeing and band spraying are hardly used by Danish farmers. Therefore, little incitement for technical refinement of machinery for row specific weed control has been demanded. In general, Danish farmers are not aware of the possibilities of adopting new technologies to improve row cultivation and spraying.

In Sweden automatic guidance systems have been adopted by farmers and approximately one third of the sugar beet area is tractor hoed and band sprayed. However, only a small proportion of this area is hoed and sprayed with machinery provided with automatic guidance. The positioning of the commercial guidance system in Sweden is based on a furrow created between rows at sowing. This is a so-called relative location technique relying on specially provided marks.

In several countries plant guidance systems are currently being developed. Many systems are computer vision-based and are capable of detecting crop rows directly by sensors. Also site oriented guidance systems are currently being developed. A Swedish system currently being developed uses a revolving laser system and a few reflectors around the field.

Development of automatic guidance systems for row specific weed control will make it possible to improve competitiveness of weed-control methods based on mechanical weed control. However, farmers do not have to wait before they replace conventional spraying with band spraying and mechanical cultivation in row crops. Economic assessments show that many Danish farmers can improve profitability immediately if they quit spraying the total area in crops with high herbicide expenses and instead use mechanical cultivation and band spraying.

The report concludes that it is already now technically possible to use automatic systems for weed control in connection with hoeing and band spraying. The available systems are based on guidance by furrows that are established in the sowing process, but other systems are being developed. Automatic systems have a number of advantages over hoeing and band spraying manually carried out. The advantages are a better exactness, which provides a reduced usage of herbicides, a greater capacity and a better work environment. In row crops the usage of herbicides can be reduced by up to 80% compared to broad spraying, which makes the method remunerative in many cases. The method is not remunerative in cereals.

The disadvantage is that it takes longer time to hoe and band spray than to broad spray. This requires the necessary time in each farm to use this method. It also requires an investment. But the greatest disadvantage is that the method is subject to some uncertainty regarding the effectiveness of it, because there is no Danish experience to draw on in the field.

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This report is subsidised by the National Council for Recycling and Cleaner Technology.

ISSN no. 0908-9195

ISBN no. 87-7810-717-2