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*Final (evaluation) Report:  
Counterpart Institution Arrangement between  
China National Cleaner Production Centre  
(CNCPC) and IVAM Environmental Research  
(University of Amsterdam) 1995-1996*

Amsterdam, May 24, 1996  
(Final version)

ENVIRONMENTAL



RESEARCH

**Final (Evaluation) Report:  
Counterpart Institution Arrangement between China National Cleaner  
Production Centre (CNCPC) and IVAM Environmental Research  
(University of Amsterdam) 1995-1996**

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## 1. Introduction

IVAM Environmental Research (University of Amsterdam, The Netherlands) has been contracted by United Nations Industrial Development Organisation in co-operation with the United Nations Environmental Programme to act as counterpart institution for the China National Cleaner Production Centre (CNCPC). The general aim of this counterpart institution arrangement is to act as supervisor to the development of the activities of the CNCPC in its key functions, respectively conducting demonstration projects in selected industrial enterprises, creating an institutional framework for Cleaner Production (CP) in China, developing and delivering training programmes and contributing to the development and implementation of CP fostering policies.

In the first year of operating as counterpart institution (between August 1995 and May 1996), IVAM Environmental Research assisted in conducting and evaluating industry specific CP demonstration projects (in respectively brewery and pulp & paper industry), provided a CP audit training for future CP auditors and provided - through discussion with CNCPC staff and development of new project activities for CNCPC - assistance in establishing the CNCPC. This final (evaluation) report contains a summary and evaluation of these activities undertaken so far and proposes activities for the coming year. Details of the field and home base work are given in the three 'progress reports' prepared within the framework of the counterpart institution arrangement, respectively:

1. *Back To Office Report (First Mission: November 18 - December 2, 1996)*: covering preparation work for the industry specific demonstration projects, participation in mid term review and training workshop for companies, review of the mid term audit report for 2 breweries and 5 pulp and paper mills and on site visits to 2 breweries and 1 pulp and paper mill;
2. *Back To Office Report (Second Mission: March 17-23, 1996)*: covering the preparation, delivery and evaluation of the CP audit training for future CP auditors;
3. *Back To Office Report (Third Mission: April 1-11, 1996)*: covering review of the final audit reports for 2 breweries and 6 pulp and paper mills, participation in review and training workshops for interested companies in both pulp and paper and brewery industry and on site visit to one brewery.

This final report is organised as follows. Section 2 summarises the results and experiences of the activities undertaken so far, in particular the industry specific demonstration projects in brewery and pulp and paper industry and the CP audit training for future CP auditors. Section 3 contains conclusions and recommendations for future industry specific demonstration projects and training activities. Section 4 deals with the follow up of this counterpart institution arrangement; it summarises both the planned activities for the second year of acting as counterpart institution as well as the initiatives undertaken to prepare and raise funds for additional CP projects in China.

## 2. Summary of activities

### 2.1 Brewery démonstration project

In 1995, CNCPC initiated in close co-operation with the Environmental Protection Bureau of Hei Long Jiang Province a Cleaner Production (CP) demonstration project in the brewery industry. From September 1995 to March 1996, 2 breweries (Qi Qi Har Brewery and Shuang Ya Shuang Brewery) received training and technical assistance in conducting a CP audit. In April 1996, a start has been made with a next round of CP audits in four breweries in Hei Long Jiang Province.

Within the framework of this counterpart institution arrangement, the representative of IVAM Environmental Research contributed in the following ways to the execution and evaluation of this brewery demonstration project:

- reviewed both the mid term and final audit reports of Qi Qi Har and Shuang Ya Shuang breweries in detail and provided remarks, suggestions and recommendations in written;
- participated in both the mid term and final review workshops with Qi Qi Har and Shuang Ya Shuang breweries and discussed comments and suggestions with representatives of the breweries and national experts from EPBs of Hei Long Jiang, Qi Qi Har and Shuang Ya Shuang, China National Council for Light Industry and CNCPC;
- visited Qi Qi Har, Shuang Ya Shuang and Yimianpo Breweries in order to discuss with staff and management obvious CP opportunities and to suggest effective strategies to identify, evaluate and implement CP opportunities;
- delivered a 1.5 day introductory training to CP auditing for companies interested in participation in the second round of CP audits in the brewery industry.

The summary of the reviews of the mill level audit reports is organised in three parts:

1. *Impression of overall achievement:* general evaluation of the execution of the CP audit and the economic and environmental benefits gained so far;
2. *Assessment of the soundness of the process evaluation and option generation:* review of the evaluation of the waste generation causes and the development and evaluation of appropriate CP options;
3. *Assessment of the accuracy and vulnerability of the feasibility studies:* review of the strong and weak points in the technical, economic and environmental evaluation of the pre-selected technology options.

The review is summarised in table 1. Based on these review comments, company specific recommendations are given in order to foster the further development and application of CP in the respective mill (table 2).

The CP options identified in the breweries have been categorised in table 3 according to the general prevention practices distinguished in China's Enterprise Cleaner Production Audit Manual, respectively 'input substitution', 'technology change', 'improvement of equipment operation and maintenance', '(technical) process optimisation', 'product modification', 'improvement of management and information systems', 'training, instruction and incentive schemes' and 'waste reuse and recycling'. Table shows that 'waste reuse and recycling' has 40 % of all options. Four other prevention practices ('improvement of equipment operation and maintenance', 'training, instruction and incentives schemes', 'technology change' and '(technical) process optimisation) are of about equal importance, with each having 10 to 15 % of the CP options considered. Table 3 also lists the anticipated (on the basis of the feasibility studies) financial savings (on an annual basis) reported for the implementation of the low and no cost options. The two breweries are able to make a joint annual saving of 4.2 million yuan. The range of possible savings for the low and no cost options ranges from 0.7 million to 3.5 million yuan annually.

Brewery	Review comments		
	1. Impression of overall achievements	2. Assessment of the soundness of the process evaluation and option generation	3. Assessment of the accuracy and vulnerability of the feasibility studies
1. Qi Qi Har	<ul style="list-style-type: none"> <li>• Audit methodology could be easily applied given past experiences in energy auditing. This lead to impressive financial savings (3.4 million yuan annually).</li> <li>• Implementation of low and no cost options seems to have been properly planned, organised and monitored, thereby creating favourable conditions for their continued implementation in the future.</li> </ul>	<ul style="list-style-type: none"> <li>• Fairly diverse spectrum of options generated over the course of the CP audit; however option screening limited the set of options subjected to detailed feasibility studies to those already considered prior to the CP audit.</li> <li>• Little seems to have been done with the suggestions provided by international sector expert (at mid term review session).</li> </ul>	<ul style="list-style-type: none"> <li>• Techno-economic evaluation of high cost options is based on comparative analysis of different types of equipment for each option.</li> <li>• Unfortunately there are a number of large and obvious calculation errors in the economic evaluations.</li> </ul>
2. Shuang Ya Shuang	<ul style="list-style-type: none"> <li>• Application of the systematic audit methodology significantly improved after the mid term review and on site discussions.</li> <li>• Implementation of first batch of low and no cost CP options has taken off and resulted in substantial savings (0.7 million yuan annually).</li> </ul>	<ul style="list-style-type: none"> <li>• Despite the fairly-superficial analysis and evaluation of waste generation causes, the audit team seems to have generated some appropriate CP options (largely based on application of example options from other breweries).</li> <li>• Little seems to have been done with the suggestions provided by international sector expert (at mid term review session).</li> </ul>	<ul style="list-style-type: none"> <li>• Technical data given for the feasibility studies are not sufficient to verify the accuracy of the economic feasibility studies.</li> <li>• Detailed feasibility studies have only been undertaken for fairly-obvious equipment modifications.</li> </ul>

Table 1: Summary of the review comments for participating breweries.

Brewery	Specific recommendations
1. Qi Qi Har	<ul style="list-style-type: none"> <li>• Expand option-inventory on the basis of the results of the site-visit (November 1995).</li> <li>• Extend the feasibility studies to all 'reasonable' equipment modifications and technology changes.</li> <li>• Cross-check and verify the economic evaluations (preferably on the basis of before-after comparisons of the material and energy balances).</li> </ul>
2. Shuang Ya Shuang	<ul style="list-style-type: none"> <li>• Substantiate the feasibility studies for the pre-selected technology-based CP options (the technical evaluation should result in an 'equipment shopping list and a projected material balance. These should both be used in the economic evaluation (with a before-after comparison of operational costs and benefits).</li> <li>• Extend the feasibility studies to all 'reasonable' equipment modifications and technology changes.</li> <li>• Develop a comprehensive CP plan based on (1) improvement of operation and maintenance status of present equipment, (2) technical optimisation and modifications in existing brewery departments and (3) inclusion of CP in capacity expansion plan (new brew house and bottling hall).</li> </ul>

Table 2: Summary of the specific recommendations for participating breweries.

Mill	number of options per general prevention practice								Estimated annual savings from low and no cost options (million yuan/year), as reported by company and CNCPC.
	product modification	input substitution	technology change	improvement of equipment operation and maintenance	(technical) process optimisation	improvement of management and information systems	training, instruction and incentive schemes	waste reuse and recycling	
1. Qi Qi Har Brewery	0	0	3	5	5	1	4	10	3.485
2. Shuang Ya Shuang Brewery	1	1	4	3	1	1	5	12	0.708
Total	1	1	7	8	6	2	9	22	app. 4.2

Table 3: Division of the CP options according to the general prevention practices in brewery industry.



## 2.2 Pulp & Paper Demonstration Project

In 1995, CNCPC initiated in close co-operation with the China National Council of Light Industry (CNCLI) a Cleaner Production (CP) demonstration project in the pulp and paper industry. Additional financial support was provided through the Network on Industrial Environmental Management: a UNEP administered network initiative to foster the uptake of Cleaner Production in technology co-operation among pulp and paper industry in South East Asia. From August 1995 to March 1996, 6 pulp and paper mills received technical and methodological assistance in conducting a CP audit from several national experts (representing CNCLI, College of Light Industry, Beijing Light Industry Institute, Provincial EPBs etc.).

Within the framework of this counterpart institution arrangement, the representative of IVAM Environmental Research contributed in the following ways to the execution and evaluation of this brewery demonstration project:

- reviewed both the mid term and final audit reports of Anqiu, Binzhou, Minfeng, Tai Zhou, Wei Hi and West Tongting (only final) mills in detail and provided remarks, suggestions and recommendations in written;
- participated in both the mid term and final review workshops with the involved mills and discussed comments and suggestions with representatives of the mills and national experts from EPBs of the home towns and provinces of these mill, China National Council for Light Industry, Beijing Light Industry Institute and CNCPC;
- visited Binzhou Pulp and Paper Mill in order to discuss with staff and management obvious CP opportunities and to suggest effective strategies to identify, evaluate and implement CP opportunities;
- delivered a 1 day introductory training to CP auditing for companies interested in participation in the second round of CP audits in the pulp and paper industry.

The review of the company level CP audits is summarised in table 4. Based on these review comments, company specific recommendations are given in order to foster the further development and application of CP in the respective mill (table 5). The CP options identified in the mills have been categorised in table 6 according to the general prevention practices distinguished in China's Enterprise Cleaner Production Audit Manual. The table shows that 'waste reuse and recycling' and 'improvement of equipment operation and maintenance' contain the largest number of options. Table 6 also lists the estimated (on the basis of the feasibility studies) financial savings (on an annual basis) reported for the implementation of the low and no cost options. Data were available for 5 mills; these are able to gain a joint annual benefit of almost 15 million yuan. Nearly half of the savings is to be achieved by just one mill (Tai Zhou). The range of possible savings due to low and no cost options ranges from 0.14 million to 7 million yuan annually.

Mill	Review comments		
	1. Impression of overall achievements	2. Assessment of the soundness of the process evaluation and option generation	3. Assessment of the accuracy and vulnerability of the feasibility studies
1. Anqiu Paper Mill	<ul style="list-style-type: none"> <li>Audit methodology generally well applied. This apparently enabled good short term economic (2.78 million yuan/yr.) and environmental benefits.</li> <li>Implementation status is however not clear for <u>all</u> low and no cost options, nor is information provided on structural changes in management and information systems and/or company organisation which can sustain their implementation.</li> </ul>	<ul style="list-style-type: none"> <li>Fairly good analysis of operational problems; causes however not traced back to obvious shortcomings in raw material cutting and cleaning, coarse screening and brown stock washing.</li> <li>Some inconsistencies in material balances.</li> </ul>	<ul style="list-style-type: none"> <li>The technology options evaluated in detail may not be the most appropriate ones for this Mill.</li> <li>Reliability of assumptions regarding automatic process control seem to be highly questionable.</li> <li>Investment for desilicon method not properly estimated; vulnerability of assumptions high given lack of industrial scale demonstrations.</li> <li>Economic evaluations not complete (feasibility indicators not calculated).</li> </ul>
2. Binzhou Paper Mill	<ul style="list-style-type: none"> <li>Audit methodology properly applied. This apparently enabled good short term economic (about 1.6 million yuan/yr.) and environmental benefits.</li> <li>Implementation status is however not clear for all low and no cost options, nor is information provided on structural - organisational changes to sustain their implementation.</li> </ul>	<ul style="list-style-type: none"> <li>Good, integrated analysis of improvement opportunities for brown stock washing and chemical recovery; implementation of such opportunities should however go alongside with improvements in straw cleaning and pulp cooking.</li> </ul>	<ul style="list-style-type: none"> <li>Techno-economic evaluation includes comparative analysis of different available technologies; reliability and accuracy of performance indicators used remains however questionable.</li> <li>Economic evaluation is too condensed to review; economic evaluation at least to be justified by before and after comparison.</li> </ul>
3. Minfeng Paper Mill	<ul style="list-style-type: none"> <li>Comprehensive and detailed CP audit geared towards three key efficiency improvement objectives in the company.</li> <li>Information regarding implementation status and benefits of obvious options is not complete.</li> <li>Impressive economic and environmental benefits (2 million Y/yr. saved on materials and energy plus 1.4 million on treatment cost), can be achieved through comparatively simple technical modifications (investment &lt; 0.5 million Yuan).</li> </ul>	<ul style="list-style-type: none"> <li>Fairly diverse spectrum of options generated; however option screening limits the set of options to those apparently accepted for implementation prior to the CP audit.</li> <li>Inter-relatedness of options not assessed.</li> <li>Several inconsistencies in option analysis and evaluation.</li> </ul>	<ul style="list-style-type: none"> <li>Technical evaluation is not consistent with monitoring data provided.</li> <li>Economic evaluation is not complete due to absence of feasibility indicators; information provided on costs and benefits is too condensed to review.</li> </ul>

<p>4. Tai Zhou Paper Mill</p>	<ul style="list-style-type: none"> <li>The audit report is limited to a summary of achievements, which in turn complicates the review of the CP audit at this mill.</li> <li>The reported short term benefits are extremely impressive (7 million yuan/yr. with only low and no cost options and significant reduction of environmental load).</li> </ul>	<ul style="list-style-type: none"> <li>Information provided on the options is very limited in particular with respect to the 24 low and no cost options which should have been implemented.</li> <li>The technology modifications for brown stock washing and improvement of chemical recovery seem to be appropriate in light of observations of (intern)-national paper experts.</li> </ul>	<ul style="list-style-type: none"> <li>No details provided on techno-economic aspects of the technical modifications currently being implemented in brown stock washing and chemical recovery.</li> </ul>
<p>5. Wei Hi General Paper Mill</p>	<ul style="list-style-type: none"> <li>Well structured and organised CP audit; substantial economic and environmental benefits achieved.</li> <li>Despite the lack of a comprehensive assessment of benefits and progress in implementation of all low / medium cost options, a good start has been made with the implementation of operational and/or managerial improvements and technical modifications.</li> </ul>	<ul style="list-style-type: none"> <li>Systematic development of appropriate CP options on basis of analysis of production problems and waste generation causes, comparative analysis of alternative technologies and smart - in house - engineering.</li> </ul>	<ul style="list-style-type: none"> <li>Alternative options for black liquor handling successfully merged for feasibility studies with improvements in cooking and washing.</li> <li>Technical and economic evaluations to be verified in light of vulnerability regarding the expected technical performance of each technology.</li> </ul>
<p>6. West Tong -ting Paper Mill</p>	<ul style="list-style-type: none"> <li>Audit methodology apparently only applied for the justification of pre-selected technical reforms to be able to operate the already installed chemical recovery system.</li> <li>Although some positive short term environmental and economic benefits have been achieved, most likely the short term, low cost CP potential still remains largely untapped.</li> </ul>	<ul style="list-style-type: none"> <li>Analysis generally based on old data.</li> <li>Comparatively superficial evaluation of waste generation causes, combined with 'stream-lined' option generation in order to arrive at pre-selected technical modifications (res. vacuum washers, extra boiler and generator).</li> </ul>	<ul style="list-style-type: none"> <li>Feasibility studies not sufficient for fund raising, since underlying problems have not been sufficiently analysed, nor have alternative solutions been subjected to a comparative evaluation.</li> <li>Assumptions regarding technical performance of washer are fairly optimistic.</li> </ul>

Table 4: Summary of the review comments for participating pulp and paper mills.

Mill	Specific recommendations
1. Anqiu Paper Mill	<ul style="list-style-type: none"> <li>• Consider improvement opportunities in raw material sourcing, cutting and cleaning, and brown stock washing and screening.</li> <li>• Re-evaluate the feasibility of the technology options on the basis of before- and after comparison of the material and energy balance taking due account of technological risks (worst and best case scenario).</li> <li>• Complete feasibility studies for all technology options before investing.</li> </ul>
2. Binzhou Paper Mill	<ul style="list-style-type: none"> <li>• Consider improvement opportunities in raw material sourcing and cleaning, optimisation of pulp cooking and modifications in existing belt washers (counter current, alternative belt material and size).</li> <li>• Substantiate the feasibility studies for chemical recovery and brown stock washing with before and after comparison of the material and energy balances.</li> </ul>
3. Minfeng Paper Mill	<ul style="list-style-type: none"> <li>• Evaluate benefits of obvious options and safeguard their ongoing implementation (through structural managerial/organisational changes).</li> <li>• Cross-check consistency of data used for the CP audit.</li> <li>• Extend feasibility studies to all reasonable technology options.</li> </ul>
4. Tai Zhou Paper Mill	<ul style="list-style-type: none"> <li>• Introduce appropriate management controls to sustain the present benefits from the implementation of low and no cost options in all aspects of the mill's operations in order to remain in profit making conditions.</li> <li>• Properly document the expectations regarding economic and technical performance of the technical modifications currently being implemented in order to keep track of progress in improving the technology and to trouble-shoot if necessary.</li> </ul>
5. Wei Hi General Paper Mill	<ul style="list-style-type: none"> <li>• Keep track of the systematic implementation of all low / medium cost options accepted and monitor the economic and environmental impact of their implementation.</li> <li>• Re-evaluate the feasibility of the technology options on the basis of before- and after comparison of the material and energy balance taking due account of technological risks/economies of scale (worst and best case scenario).</li> </ul>
6. West Tongting Paper Mill	<ul style="list-style-type: none"> <li>• Avoid future pitfalls of the magnitude of the investment in the chemical recovery which can still not be operated.</li> <li>• Identify short term improvement opportunities (managerial and operational improvements and minor technical modifications) to improve raw material cleaning and brown stock washing and conserve energy (housekeeping, insulation etc.), thereby creating a lower cost scenario to start up the chemical recovery.</li> <li>• Assess the root problems of poor raw material quality, poor pulping efficiency and brown stock washing in order to develop a sound technical innovation plan for the longer term.</li> </ul>

Table 5: Summary of the specific recommendations for participating pulp and paper mills.

Mill	number of options per general prevention practice								Estimated annual savings from low and no cost options (million yuan/year), as reported by company and CNCPC.
	product modification	input substitution	technology change	improvement of equipment operation and maintenance	(technical) process optimisation	improvement of management and information systems	training, instruction and incentive schemes	waste reuse and recycling	
1. Anqiu Paper Mill	0	0	6	1	1	2	1	2	2.78
2. Binzhou Paper Mill	0	1	2	2	1	1	1	5	1.6
3. Minfeng Paper Mill	0	1	3	16	6	2	3	7	3.4
4. Tai Zhou Paper Mill	0	0	1	2	2	1	0	2	7
5. Wei Hi General Paper Mill	0	1	3	3	2	2	1	6	?
6. West Tongting Paper Mill	0	0	3	0	1	1	1	2	0.14
Total	0	3	18	24	13	9	7	24	app. 15

Table 6: Division of the CP options according to the general prevention practices in pulp and paper industry.

## 2.3 Audit training

Within the framework of this counterpart institution arrangement a Cleaner Production Audit Training has been developed and delivered for future Cleaner Production Auditors. The training workshop had a twofold objective:

1. to provide an introduction to CP audit based on the experiences gained so far in promoting CP in China;
2. to explain and practice how a CP audit can be undertaken in different types of industries;

It was envisioned that the participants in the training workshop can act as CP auditors and advisors to industries in their home provinces. The training was hosted by the Cleaner Production Department of the Shaanxi Environmental Protection Bureau and held in Xi'an on March 19-21, 1996.

China's Enterprise Cleaner Production Audit Manual was used as core for the training. The training workshop was organised around lectures and working sessions in four small groups (each approximately 8 participants). The lectures provided an in depth introduction to CP auditing illustrated with examples from audits undertaken within the framework of the World Bank CP project. During the working sessions, the participants worked on an audit exercise, for respectively a pulp and paper mill and a chemical factory. The audit exercises have been developed by IVAM Environmental Research on the basis of experiences of real companies in order to illustrate and practice the execution of the CP audit. The results of the group working sessions were presented to all participants and used for additional discussion.

The training was attended by some 30 participants. Around 20 participants came from Environmental Protection Bureau's, Environmental Research Institutes and industrial authorities outside Shaanxi Province (amongst others from Henan Province, Hei Long Jiang Province, Shandong Province, Shanghai and Tianjin). Around 10 participants came from Shaanxi Province, in particular from the Environmental Protection Bureau, its associated institutions and a few interested industries. The industrial sectors of interest for the participants were light industry, chemical, fertiliser and pharmaceutical industry and electronics industry).

This training illustrated to CNCPC and other stakeholders in China how an interactive CP audit training can be organised and delivered. The participants were generally very positive, despite the obvious bottlenecks encountered, such as non availability of a Chinese translation of the audit exercises, minor differences in the audit method used in the exercises and in the Chinese manual, lack of practical - visual - illustration and some inconsistencies in the Chinese audit manual. Most of the participants had anticipated a typical lecturing course and had to get used to the group work at first, but started to appreciate this even more as the training workshop evolved. The question remains as to what the influence of a foreign lecturer has been? Would it have been as easy for a Chinese trainer to incite the participants for such a lot of participants' input and interaction ?

## 3. Conclusions and recommendations

### 3.1 Industry specific demonstration projects

#### Lessons learned

The execution of the CP audit lead to positive results in all companies. Each of the companies, as well as the team of involved national experts, became enthusiastic for CP. Most importantly is however the fact that on average substantial financial savings as well as environmental improvements could be gained. The demonstration projects thus clearly illustrated the existence of a fairly large and diverse CP potential in medium sized non-wood pulp and paper mills and breweries.

The following five conclusions - or lessons - have been drawn from the overview of the audit results in the industry specific demonstration projects:

**Lesson # 1: There are large differences in the baseline performance of the companies in the same industry sector.**

This is particularly evident in the pulp & paper industry. Although all mills use highly comparable equipment, processes and raw materials, the baseline performance differs substantially. The comparative analysis of the audit reports illustrates the following ranges for the material consumption:

- chemical consumption: 264 to 360 kg/ton pulp (+ 36 %)

- raw material consumption: 2323 to 3288 kg/ton pulp (+ 41%)
- antraquinone consumption: 1 to 6.78 kg/ton pulp (+ 675 %)
- water consumption: 19 to 290 ton/ton pulp (+ 1425 % %).

It goes without saying that these figures have to be verified and evaluated in light of company specific circumstances and pulping parameters (like cooking curve (time- temperature-pressure diagram), charging density etc.). However, this preliminary analysis already points out that the mills can learn from each other to conserve water, chemicals and materials. It would therefore be most useful to look into detail in the differences in the processes and operating practices in order to define the best practical means for operating a non wood pulp mill.

A similar case can be made in order to illustrate the same type of differences in performance between different breweries. To that end it would be most useful to actually compare the findings at Qi Qi Har and Shuang Ya Shuang Breweries with those obtained at the breweries which participated in the World Bank CP project (in particular Beijing Brewery and Penglai Brewery).

**Lesson # 2: 'Root' problems in the sector need a combined effort of companies, technical institutes and environmental and agricultural authorities.**

Almost all companies in the respective industry sectors are confronted with almost identical technical problems, and none of the companies is capable of really solving these problems on its own. This finding underscores the need for concerted action among companies, facilitated by environmental and agricultural authorities and supported by technical institutes.

Among the most apparent root problems for breweries are:

1. *optimisation of processes and operations* (in wort production, fermentation and filtration); the *environmental burden* (waste water load, energy and water consumption) is to a large extent determined by the efficiency in wort production, fermentation and filtration. Although most breweries seem to have implemented - computer - controls for optimisation of fermentation, optimisation of processes in wort production and operations throughout the brew- and fermentation house, seems not to have taken off. Substantial savings can apparently be made by operation of for instance 'weak wort' and 'wash water' tanks, use of fixed pipes instead of hoses, etc.. This type of optimisation efforts will most likely also have a positive impact on product quality;
2. *minimisation of beer losses with dregs (spent grains) and yeast and in filtration*; in particular in small and medium sized breweries still a comparatively large amount of beer is lost with the by-products, in particular dregs (spent grains), spent yeast and filtration medium (diatomae etc.). Proven technologies to recover beer (and yeast) from these by-products are only available for medium to large scale breweries (including beer centrifuge, filter press etc.). However, appropriate technologies for the numerous smaller scale breweries are still to be developed and demonstrated in practice.

The most apparent root problems for pulp and paper industry are:

1. *raw material sourcing and preparation*: the raw material is generally too rich in impurities, in particular non fibrous parts of the plants (in particular leaves (reed, straw, bagasse), chaff (straw) and pith (bagasse)) and unwanted additions (sand, stones, oil, water etc.). The quality of the raw material is to be improved through a combination of the following approaches:
  - co-operation with farmers to harvest with a view to using the residue (straw, etc.) for pulp making;
  - co-operation with traders to avoid unwanted additions;
  - improvement of raw material cutting and cleaning.

In order to improve raw material quality and thereby reduce chemical, water and energy consumption in pulp production, it will be necessary to establish co-operation with farmers and traders and educate them.

2. *black liquor segregation and treatment or recovery*: The discharge of concentrated and diluted black liquor is the single largest source of COD and TSS in the pulp and paper mills, and therefore effective strategies and technologies have to be developed to segregate and treat or recover at least the concentrated black liquor. In theory chemical recovery - based on evaporation, combustion and causticizing - is the preferred option since it destroys (burns) the organic components and recovers the residual alkali for reuse in the pulping process. Given the numerous problems in operating chemical recovery, it is most promising that alternative black liquor treatment and recovery techniques are being developed and considered by the mills. However, there are major differences in the expected efficiency of different processes (in particular production of liginosulfonate, alkaline lignin separation, desilicon method). Given the numerous and large

differences in expected performance for the alternative black liquor treatment and recovery technologies, it would be most useful if industrial authorities could initiate a real practice comparative evaluation of these alternative technologies in order to find out for which type of mills a particular treatment and/or recovery technology could be most appropriate and economically and technically feasible.

3. *optimisation of pulp cooking and bleaching processes*: the bleached pulp yield is the most important performance indicator for the pulp mill. As evidenced by the reports, the mills hold different opinions as to how to improve the pulp yield. This illustrates the need for support for the mills in their efforts to raise the pulp yield.

**Lesson # 3: The quality of the company level CP audits conducted within the framework of these industry specific demonstration projects in the brewery and paper industry seems to be - on average - slightly lower than the quality of the audits conducted in the framework of the Word Bank/UNEP CP project (Improving Cleaner Production in China).**

Although difficult to assess quality of a CP audit, it may be argued that quality of any audit is to be related to the *practical value* of the audit (the environmental improvements and financial savings achieved), the *technical impact* (the impact of the audit on the development and application of technology in the company) and the *systemic impact* (contribution of the audit to the establishment of a management and information system and organisation structure which fosters ongoing environmental improvements). Without going in detail, in general it is felt that the practical value of the audits is still fairly good (with substantial financial savings and environmental improvement for the companies audited), but that - on average - the audits hardly have a technical nor a systemic impact.

It is felt that the problem of the limited quality of the audits is at least partially caused by:

- *strong emphasis on preparation of a proper audit report*; it may appear to the companies and experts involved that preparation of a high quality audit report is more important than the actual implementation of CP options and development of CP supporting management changes in the companies. This emphasis on the audit report is to some extent justifiable since it provides at least written evidence for the CP activities in the companies and enables a review of these CP activities by the outside experts (staff members of EPBs, technical institutes, China NCPC and foreign consultants). Despite this it is strongly recommended to target the assistance to the companies to enabling the company level audit team to implement CP in practice and to give only second priority to assisting companies in preparing audit reports.
- *methodological limitations* (in China's Enterprise Cleaner Production Audit Manual); it goes without saying that this audit manual has enabled the companies to identify, evaluate and implement CP options in an organised and systematic way. However, it is also to be acknowledged that in almost every audit reviewed so far, highly comparable problems have been identified, due to either a too vigorous application of the audit manual or the lack of specific tools for some tasks in the audit manual. It is felt that such problems can be avoided by a revision/improvement of the audit manual.

**Lesson # 4: Ongoing implementation of low cost options regarding 'improved equipment operation and maintenance', 'training, instruction and incentive schemes' and 'improvement of management and information systems' calls for structural and irreversible changes in management and information systems within the mill and in their internal organisation structure.**

The substantial financial savings reported in the audit reports (and summarised in tables 3 and 6), are mainly the result of the vigorous application of housekeeping improvements, training, repair of equipment etc.. The ongoing implementation of this type of options is completely dependent on motivation and attitudes of workers, supervisors, managers and engineers. Over the course of time this motivation may slip away, returning to the wasteful production practices which were accepted as normal before the CP audit. In order to avoid this to happen, a serious effort is needed from the mills to initiate irreversible changes in management and information systems within the mill and in the internal organisation structure.



## **Lesson # 5: The added value of having industry specific demonstration projects is still to be elaborated and explored.**

In the planning of the activities of the China NCPC it has been decided to undertake the CP demonstration projects per industry sector. This decision was based on the assumption that doing so, would create added value, as opposed to having CP demonstration projects on a cross industry sector basis. This added value could be:

1. cross fertilisation and exchange of good housekeeping practices, prevention options etc. among companies participating in the demonstration project;
2. identification of common issues - technical and environmental problems - which cannot be solved by a single company but may be solvable though joint action in technology development, evaluation and transfer;
3. higher efficiency of assisting the companies in conducting the CP audit

The comparative analysis of the audit results in the demonstration projects so far indicates that at present these added values are not fully exploited. It is felt that this may have been caused by the design and organisation of the industry specific demonstration projects so far. Until now the demonstration projects have essentially been undertaken and managed as a set of independent company level CP audits. The division of the workload is made by appointing a team of at least two national experts to assist one company; apparently nobody is responsible for making a comparative analysis of the company level CP audits nor has the authority and/or opportunity to undertake action to attack common issues and to foster exchange of results and experiences among the participating companies.

### **Recommendations**

The recommendations for future CP demonstration projects are organised in two categories, respectively:

1. recommendations for improvement of the planning and management of demonstration projects;
2. recommendations for improvement of the execution of company level CP audits;

Each is elaborated below.

#### **Area # 1: Improvement of the planning and management of demonstration projects**

It is of utmost importance to make sure that undertaking a demonstration project goes beyond the completion of several CP audits in selected example companies. To this end the following is recommended:

1. *to design demonstration projects with an 'in built' dissemination and replication potential:* right at the start of the demonstration project a strategy has to be developed on how to publicise the results of the demonstration project and by what means these publicised results will be disseminated to other - interested - companies. To this end, it will be necessary to think about both the type of information products (booklets, fact sheets, audit manuals, etc.) and services (training, on site technical assistance, etc. ) used for the dissemination of CP as well as the means by which these products and services can be effectively brought to the attention of companies that may benefit from it. This actually calls for a close match between the demonstration projects and the training and policy activities.
2. *to use demonstration projects to develop streamlined - or abridged - audit tools:* in particular after conducting a series of maybe 5 or 10 audits in illustrative companies in one industry sector, it should be possible to develop and apply a streamlined audit tool, which enables other interested companies to identify - most of the - CP options with a much smaller burden on staff resources than executing a full sized audit (according to China's Enterprise Cleaner Production Audit Manual). The development of such streamlined audit tools will ease the acceptance of CP by other potentially interested companies, thereby enabling a multiplier in the uptake of CP in a particular industry sector.
3. *to extend the duration of the assistance and support by - national - experts to the companies:* at present, the support seems to stop after completion and submission of the final audit report. Therefore it is not known in detail what problems companies faced in the actual implementation of CP options considered feasible and what in practice the results of the implementation of CP options were. It is generally felt that a much stronger case can be made to convince other companies, if the case studies are based on actual measurement of the improvements a significantly long period after implementation of the options. Instead of example audit reports, it may then be possible to write and disseminate real 'success stories'.
4. *to improve the review process for the audits:* since it is found that hardly any mid term review comments and suggestions have actually been incorporated in the final audit reports, it is felt that little is actually done with the comments and suggestions generated at both the mid term and the final review of the company level audit reports. It is therefore suggested to develop more appropriate procedures which allow inclusion of the review comments and suggestions in the audit work undertaken by the company level audit teams.

The above recommendations call for changes in the management of industry specific demonstration projects. For the continuation of the industry specific demonstration projects in breweries and pulp and paper mills it is therefore recommended to improve the management of the demonstration project, in such a way that it is more likely that undertaking simultaneously CP audits in several companies can create added value. To this end it is thought necessary:

1. to put one institution (or even person) in charge of the comparative analysis of the progress in the company level CP audits and of the preparation of action plans for technology development and/or demonstrations to attack common problems in the sector;
2. to foster periodic (for instance monthly) exchange of results and experiences among the CP auditors involved in the CP audits in the participating companies;
3. to develop - on the basis of the audit results - an abridged audit tool and success stories in order to foster the dissemination of CP within the sector upon completion of the industry specific demonstration project

## **Area # 2: Improvement of the execution of company level CP audits**

It has been noted that in almost every audit reviewed so far, highly comparable problems have been identified, due to either a too vigorous application of - parts of - the audit manual or the lack of specific tools for - selected - tasks in the audit manual. It is felt that such problems can be avoided by a revision/improvement of the audit manual. The most important suggestions for such revision of the audit methodology are:

- avoid the need-less use of weighted sum analysis (for the selection among alternative audit focuses and among alternative CP options);
- improve link between cause evaluation and option generation: this is possible through inclusion of lists of mutually inter-related standard cause categories and standard prevention practices. In the audit training sheets (developed for the auditors training) a detailed proposal has been made for standardised cause categories and prevention practices;
- organise options into coherent option programmes: between option generation and option screening the generated options have to be organised in consistent option programmes. This includes: organising options per unit operation, evaluation of mutual interferences among options, implementation of obviously-feasible options and elimination of obviously-non-feasible options. Doing so will actually reduce the number of options to 'reasonable' option programmes only. In case the number of reasonable option programmes is limited (up to 8 or 10 option programmes), it is actually recommended to complete the detailed feasibility studies for all these reasonable option programmes before deciding to invest in any of these;
- improve the transparency of the feasibility studies: at present it is almost impossible to review the consistency of the feasibility studies. The transparency of the feasibility studies can be significantly improved, by:
  1. making sure that the technical evaluation results in both an equipment shopping list (specifications for equipment to be purchased and installations to be constructed in order to implement the option) and projected material and energy balances (expected figures after implementation of the respective CP option);
  2. making sure that the estimation of the investment costs is based on the 'equipment shopping list' derived from the technical evaluation of the respective option;
  3. making sure that the economic benefits are calculated on the basis of a before and after comparison of the material and energy balances; The 'before' situation is to be derived from the material balanced developed in the assessment phase, but corrected for the impact of the implementation of the low and no cost options. The 'after' situation is to be derived from the projected material and energy balances (prepared as a result of the technical evaluation).
- improve the suggestions given for anchoring the continuation of CP in the company: the present recommendations were derived from initial experiences during the Preparation Phase of the World Bank CP project. Right now a much better insight has been gained in factors governing the actual uptake and continuation of CP at the level of a single enterprise. It therefore seems most useful to rewrite the section on phase 7 (Sustainable CP). While doing so, it may be considered to include the preparation of an annual CP progress report as one of the constituent tasks for this phase.

### 3.2 Training and information dissemination

The apparent success of the first train the auditors workshop is of course to be monitored and evaluated over the coming time. Most importantly China NCPC should try to keep in contact with all participants in this workshop in order to assess to what extent the participants have really undertaken CP activities following their participation in this training workshop. The information obtained from this follow up can be used for the further development of a training, dissemination and communication strategy for CP in China.

For the time being, it seems however justifiable to anticipate on the need for repetition of this type of interactive CP audit training workshop for future auditors. For the practical preparations of such training workshops, the following is recommended:

1. *Make sure that both sheets and audit exercises are available in Chinese to all participants at the start of the workshop:* for future workshops it may be considered to use audit exercises for other sectors of industry;
2. *Include practical and visual presentations of CP achievements into the training programme:* it would be most useful to include a working visit of 0.5 to 1 day to an interested company. The trainees could get a specific instruction for the visit; the results (for instance suggestions for low and no cost options etc.) could then be presented to the company management and be evaluated among the trainees.
3. *Postpone the lecture on audit skills and tools (part 2 and 3 of the introductory lecture) to the last session (after going in depth through phase 1 - 7 of the audit manual).*

In addition to training of future auditors and companies, it deserves recommendation to prepare a comprehensive training and information dissemination strategy for CP in China. While doing so, the following may be considered:

1. *to expand training to industrial, planning and agricultural stakeholders:* at present the training and communication efforts only target at staff of Environmental Protection Bureau's (at level of Provinces and Cities) and Environmental Protection Institutes of technical institutes and industrial ministries. In order to accelerate the uptake of CP in China's industry it will be of crucial importance to start networking activities with other industrial, planning and agricultural stakeholders (including for instances planning and standardisation departments of the various industrial ministries, Ministry of Agriculture, Ministry of Education, State Science & Technology Commission, etc.). Different types of short and long interactive training and communication activities will be necessary in order to smoothen the development and operation of this network for the promotion of CP in China;
2. *to target the content of the training to the actual needs and capacities of the target training group:* right now apparently all training is based on the content of China's Enterprise CP Audit Manual. However, only companies and technical advisors to companies can actually use this audit manual in conducting factory level CP audits. Other target groups - like environmental and industrial authorities - hold different roles in promoting CP, and may therefore be trained more efficiently with other materials, for instance with specialised training on CP policy instruments and enforcement strategies, communication and training skills (to convince companies), bench-marking techniques etc. etc.;
3. *to provide proper follow up to training activities:* as the number of people trained in CP increases, it becomes increasingly important to keep track of the activities that participants of different training workshops undertake as a result of their participation in a particular training workshop. To this end it may for instance be considered to send on a periodic basis questionnaires to participants from specific training workshops in order to monitor the impact of the training.

### 4. Follow up

It is envisioned that the co-operation between China NCPC and IVAM Environmental Research is extended and expanded in the coming period. To this end, several joint project activities have been planned, most importantly:

- preparation of work proposal for continuation of the counterpart-institution arrangement;
- development of CP project proposals for bilateral environmental technical assistance;

Both initiatives are shortly elaborated below. Additionally China NCPC and IVAM Environmental Research have expressed their interested and presented their capacities to undertake selected projects already under preparation by other agencies (like Administrative Council for China's Agenda 21, World Bank, UNIDO (in particular for GEF project on pollution abatement in TVIE's) etc.).

Both China NCPC and IVAM Environmental Research are satisfied with the results obtained from the first year of operating as counterpart institution. Therefore, a draft work proposal has been prepared to continue the counterpart activities for the coming year. The activities in this work proposal, aim:

1. to provide *technical and methodological assistance* for the execution of the CP demonstration projects in the brewery industry (4 breweries in Hei Long Jiang Province) and pulp & paper industry (8 mills in Huaihe River Basin);
2. to provide guidance to the establishment of a comprehensive CP *training and information dissemination strategy* for China NCPC;
3. to provide *institutional support* for establishing China NCPC and the development and evaluation of its workplan and for initiating additional CP activities in China in co-operation with China NCPC.

A detailed work proposal is added as annex to this final evaluation report.

The Dutch Government is about to launch an environmental technical assistance programme to China. IVAM Environmental Research in co-operation with China NCPC has submitted two project proposals for inclusion in this technical assistance programme. These are:

1. *Capacity Building for Identification, Evaluation and Dissemination of Cleaner Production Practices and Technologies in Selected Industries in Sichuan and Guandong*: This project proposal has been developed with a view to combine capacity building in two provinces which did not yet start Cleaner Production activities (respectively Guandong and Sichuan) with the development and trial application of streamlined audit approaches for two industry sectors (a summary of the project proposal is given in box 1);
2. *Evaluation and Transfer of Engineering Small Wares to Improve Energy and Resource Efficiency in Key Industries in China*: This project proposal aims to broker market driven technology co-operation and transfer deals between Dutch and Chinese equipment designers and manufactures, in order to initiate marketing, and possibly even manufacture, of such engineering small wares in China. The adoption of such small wares by companies from different sub-sectors of China's industry will in turn enable these companies to improve their energy, material and water efficiency significantly (a summary of the project proposal is given in box 2);

The first project proposal strongly builds upon the recommendations given to improve the design and management of industry specific demonstration projects (see also section 3.1), while at the same time contributing to professional training for future CP auditors in selected provinces (in accordance with recommendations given in section 3.2). The second project proposal seeks to expand the activities of CNCPC by actively involving CNCPC in the preparation and evaluation of technology transfer and co-operation deals. A decision on the above project proposals is expected during summer of 1996.

The execution of the project, aims to:

1. build in both Guandong and Sichuan a team of provincial experts which can conduct Cleaner Production audits in companies and can contribute to the dissemination of Cleaner Production to industries in the respective provinces;
2. develop and evaluate ways to streamline the Cleaner Production audit approach for two industry sectors.

The development of streamlined (or abridged) methods is thought necessary in order to be able to reach a significant share of the around 5 million medium to large industrial enterprises in China over the coming years. In the development and trial application of streamlined methods, attention will be given to make sure that the company's effort for the implementation of Cleaner Production can be reduced, without compromising too much on the quality and sustainability of the Cleaner Production achievements in the respective company.

The provincial teams in Guandong and Sichuan will consist of approximately 8 to 10 persons, representing different institutions, such as the provincial Environmental Protection Bureau, Industry Departments from the provincial economic councils, Environmental Protection Research Institutes, technical and research institutes. The teams will be co-ordinated by respective provincial Environmental Protection Bureau. As part of the project, each team will execute Cleaner Production Audits in three 'demonstration' companies in one industry sector (according to the specifications given in the *'Enterprise Cleaner Production Audit Manual'*) under the guidance of China NCPC and with assistance from IVAM Environmental Research and industry specific experts. In addition, each provincial team will assist 12 companies in the same industry sector in executing a *'self-audit'*, according to the industry specific audit kit developed in the course of the project.

The results of the detailed audits in 3 'demonstration' companies in 2 sectors will be used by China NCPC to develop the *industry specific audit kit* for the respective industry sectors, with assistance from IVAM Environmental Research. This industry specific audit kit should enable interested companies to start with the identification and evaluation of Cleaner Production opportunities with *minimal* assistance from outside experts ('self-audit'). The results achieved in the companies will be monitored and evaluated in a summary report, which in turn will be used to interest other companies and institutions to undertake Cleaner Production activities. To this end a national seminar will be organised at the end of the project.

Box 1: Summary proposal "Capacity Building for Identification, Evaluation and Dissemination of Cleaner Production Practices and Technologies in Selected Industries in Sichuan and Guandong"

In order to prepare the stage for the desired market-driven technology transfer and co-operation deals, the project aims to achieve the following sequence of intermediate objectives:

1. to assess the need for engineering small wares for the improvement of the energy and resource efficiency of key industry sub-sectors in China;
2. to demonstrate, and evaluate, in practice, the economic and environmental benefits of the application of particular types of high quality engineering small wares in key industry sub-sectors in China;
3. to assess the Chinese market for the market driven adoption of the proven high quality engineering small wares;
4. to identify potential market parties (equipment designers and manufacturers) on both the Chinese and Dutch side which may be interested in a technology deal to market, and possibly manufacture, the respective type of small wares in China, and to bring these potential market parties together.

The project adopts an industry specific focus for the identification of the technical needs for engineering small wares in China's key industries. Once a particular set of engineering small wares is being demonstrated and evaluated, a cross industry sector approach will be adopted in order to explore the possible market for this tested set of engineering small wares.

Box 2: Summary proposal "Evaluation and Transfer of Engineering Small Wares to Improve Energy and Resource Efficiency in Key Industries in China".

## **Annex 1:**

### **Work Proposal 1996-1997: Counter Part Institution Arrangement between China NCPC and IVAM Environmental Research**

#### **Specific objectives**

The specific objectives for the counterpart institution support in the period between August 1996 and April 1997 are as follows:

1. to provide *technical and methodological assistance* for the execution of the CP demonstration projects in the brewery industry (3 breweries in Hei Long Jiang Province) and pulp & paper industry (8 mills in Huaihe River Basin);
2. to provide guidance to the establishment of a comprehensive *CP training and information dissemination strategy* for China NCPC;
3. to provide *institutional support* for establishing China NCPC and the development and evaluation of its workplan and for initiating additional CP activities in China in co-operation with China NCPC.

#### **Workplan**

In accordance with the specific objectives, the workplan has been divided in three major activities. The detailed tasks for each activity are specified below. The activities are partially undertaken from home base and partially in the project area. In case of written report, the report will be distributed to CNCPC, UNIDO Environment and Energy Branch and UNEP Industry and Environment.

##### **Activity 1: Technical and methodological assistance for industry specific demonstration projects**

This activity includes the following tasks:

- 1.A.1. Review 3 brewery mid term audit reports and provide comments and suggestions in written.
- 1.A.2. Participate in mid term review and training workshop for breweries at one of the participating breweries and provide on site guidance to 2 or 3 breweries (depending on location).
- 1.A.3. Review 3 brewery final audit reports and provide comments and suggestions in written.
- 1.A.4. Participate in final review workshop for breweries at one of the participating breweries.
- 1.B.1. Review mid term audit reports for 8 pulp and paper mills and provide comments and suggestions in written.
- 1.B.2. Participate in mid term review and training workshop for pulp and paper industry at one of the participating mills and provide on site guidance to 3 or 4 mills (depending on location).
- 1.B.3. Review final audit reports for 8 pulp and paper mills and provide comments and suggestions in written.
- 1.B.4. Participate in final review workshop for pulp and paper industry at one of the participating mills.

##### **Activity 2: Guidance on training and information dissemination**

This activity includes the following tasks:

- 2.A. Collect background information on different approaches adopted in CP training and information dissemination and provide this to CNCPC.
- 2.B. Prepare and deliver a 3-4 day interactive CP audit training for some 30 to 40 future Chinese CP auditors.
- 2.C. Advice on the development of different training and information dissemination products and services (like exercises, fact sheets, case studies, etc.) for different target groups (including companies, environmental and industrial authorities, etc.).

##### **Activity 3: Institutional support**

This activity includes the following tasks:

- 3.A. Act as a sounding board for development of new CP activities and projects in China in particular related to - but not limited to - training, technology transfer and environmental management systems.
- 3.B. Assist in drawing overall conclusions from the CP demonstration projects and provide recommendations for future CP activities in pulp & paper industry and brewery industry as well as for the planning of industry specific demonstration projects in other industry sectors.
- 3.C. Review the draft annual report for 1996 as well as the draft workplan for 1997 of CNCPC and provide comments and suggestions in written.

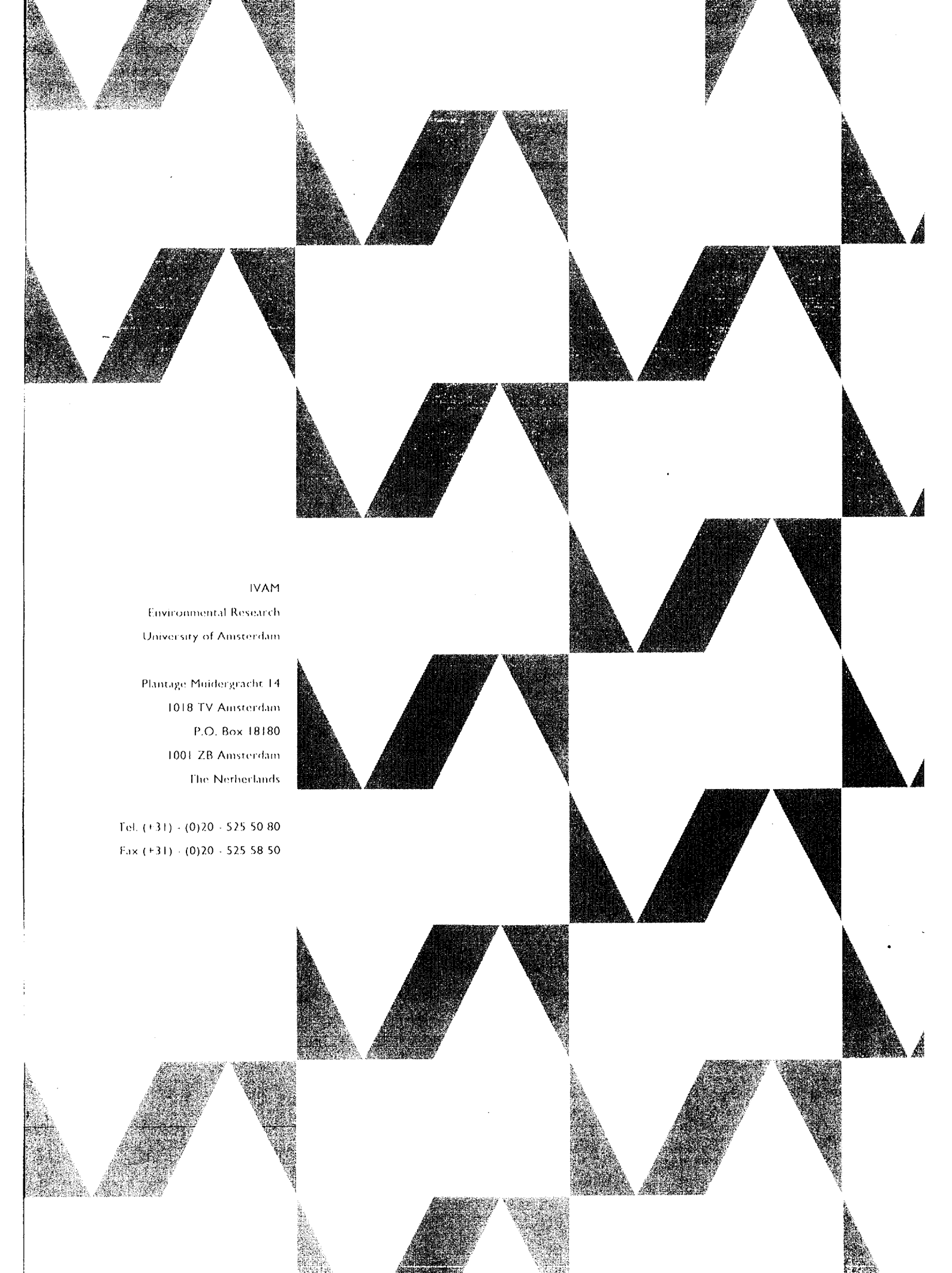
- 3.D. Prepare a final report regarding the results and experiences of the activities undertaken within this Counterpart Institution Arrangement in the year 1996-1997.

### **Planning and organisation**

The work will be undertaken from home base (Amsterdam) and in the project area (in particular Beijing, Hei Long Jiang Province and Huaihe River Basin). To this end three missions will be undertaken of each 8 working days (about 10 days stay in China).

- One mission will be spent to the mid term review and company visits in pulp and paper industry (task 1.B.2);
- One mission will be spent to the mid term review and company visits in brewery industry (task 1.A.2) and delivery of the CP audit training (task 2.B);
- One mission will be spent to final review in both brewery industry (task 1.A.4) and pulp and paper industry (task 1.B.4).

Subject to detailed arrangements with CNCPC, the first two missions will tentatively be undertaken in September-October 1996, with at least an interval of 22 days between these two missions. The third mission will tentatively be undertaken in February 1997. In order to properly prepare for each mission, the respective mid term and final audit reports should be available in The Netherlands, at least 15 days prior to the start of the respective mission.



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