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Cleaner Production in Breweries

A Workbook for Trainers

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First Edition • March 1996

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Industry and Environment
Environmental Training Unit
UNEP

Cleaner Production in Breweries

A Workbook for Trainers

This package is one of a series that provides practical support material to teachers and trainers wishing to commence or enrich their curriculum with up-to-date approaches in environmental management.

It is based on extended experience with training workshops by UNEP and other agencies, and is now being made available for wider use in all regions throughout the world.

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Further advice and editing and supplementary material was provided by Hugh Carr-Harris, John Kryger, Fritz Balkau, and Sybren de Hoo within UNEP IE. Michael Atchia from the Environmental Training Unit in UNEP provided encouragement and advice.

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Cleaner Production in Breweries

Users Guide

This is a trainers support package, *not* a reference book. It does not give a systematic, comprehensive overview; rather, it focuses on some selected aspects that are central to the subject. The structure of the document allows further sections to be easily developed and added as additional modules.

The package is written for trainers to provide them with support material and ideas, rather than as a study book for students. The average trainee will only ever see a few pages or exercises reproduced from this document.

One of the purposes of this package is to provide some case studies and situation scenarios that can be used as a basis for interactive training and simulated decision-making. However, the exercises only explore a small part of the potential of the case studies, and trainers are strongly encouraged to develop further exercises or tasks.

The package is oriented at developing insights and decision-making skills. For teaching the factual knowledge base of the subject, trainers are referred to the reading lists in the bibliography.

Work exercises are predominantly based on interactive groupwork and a team approach to problem-solving. Such work needs to be guided by a tutor who is a recognized expert in the field. This method allows the full complexity of real decision-making to be explored.

Where calculations are required, the exercises are more oriented towards throwing light on useful approaches or management decisions than simply finding the 'correct' answer. Trainers are strongly urged not to see this package merely as a set of arithmetic exercises.

In some instances, answers are indicated. The 'correct' answer depends on the context of the question. It is here that a tutor or external resource expert is useful.

Many trainers find this disturbing. They should remember that real decision-making depends on the wider circumstances surrounding the problem, and that a numerical answer which is politically or socially unacceptable, or administratively unworkable (even though accurate), is not in effect 'correct'.

The simulation of real life situations and decision-making that is the basis of this package makes it most suitable for senior students and trainees, and especially for professional training (or retraining) courses.

Do not forget to also refer to the package on *Cleaner Production* for teaching the underlying concepts and approaches in this workbook.

Finally, we must stress again that this package does not cover all aspects of the subject. Its prime purpose is to lead trainers into this field, and to help and encourage them to develop their own material, appropriately tailored to their specific learning situation. UNEP is prepared to work further with trainers who wish to extend this package into new directions, or go into greater depths on some subjects.

How to start a training activity based on this package

1 ***Remember that this is a starters kit***, not a complete recipe book. Remember also that the workbook aims to develop insights and decision-making skills, not to convey knowledge or facts.

2 ***Understand the needs of your trainees***. What insights or skills do you intend to develop? Define your learning objectives.

3 ***Refresh your memory*** by reading some of the background papers and studying the overhead transparencies. Write your own notes in the spaces provided.

4 ***Identify some expert resource persons*** who could be invited as tutors to help you in discussion sessions.

5 ***Select some of the exercises*** you wish to present to trainees.

6 ***Examine carefully the case study or scenario*** on which they are based. Be sure that you have at least one solution to the exercise that you can explain and defend.

7 ***Develop other exercises*** or questions yourself.

8 ***Develop your own local case study*** if you can, and use this instead of the one in the package.

9 ***Prepare some background questions*** and preliminary exercises for trainers to carry out before they start the workshop/course.

10 ***In session, summarize the issues*** for trainees using the overheads given, and others you may have. Discuss the problems and difficulties decision-makers face. Discuss where factual information can be found to help in decision-making.

11 ***Commence the work sessions***, preferably in small groups, and preferably guided by a tutor. Discuss and compare results. Be open to ideas and experiences from trainees, and discuss these.

12 ***Return to the learning objectives***, and check that they have been achieved.

13 ***Consider how to follow up*** and reinforce the learning experience by establishing some ongoing projects, or periodic reunions.

Refer also to other packages and workbooks, where useful additional teaching material is found.

To facilitate using this package, the header of odd-numbered pages describes the contents of that particular section. This information is also repeated in the footer of even-numbered pages. You can track your progress through the package by referring to the calibrations on the bar across the bottom of odd-numbered pages:

The shading shows your current position in the text.

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Part 1
Introduction

1 Introduction

Many teaching institutions and individual trainers have difficulty in following the rapid evolution of environmental issues that are relevant to their courses.

This is particularly true when teaching subjects such as pollution and environmental management. And yet it is important that new graduates have a good knowledge of issues in which they may eventually provide consulting services or policy advice to governments and industry.

The fact that development and environment are interrelated means that it is more vital than ever that:

- *all professionals have a basic environmental literacy that helps them to incorporate environmental priorities into their specialized work, whatever their profession;*
- *specialized environmental courses are relevant to today's environmental agenda.*

In 1993, in response to these findings, UNEP, WHO, and ILO jointly initiated the programme on Training Approaches for Environmental Management in Industry. The programme aims to enhance the capacity of national institutions to offer local training on topics concerned with the prevention of industrial pollution.

In this context, trainers' packages have been prepared on different areas of environmental management. These packages are intended to help educators and trainers to develop their own workshops or curricula, or to integrate some of the ideas and information into already existing teaching programmes.

It is important to keep in mind that these training resource packages merely provide a first orientation to the topic.

In no way does the package constitute a 'course' in its own right.

1.1 This package

This package is a workbook that complements the trainer's package on *'Cleaner Production'*. For best results, both should be used together. In many cases, it would be useful to use the Cleaner Production material as an introduction to any curriculum-based material in this workbook.

The workbook is balanced between curriculum-based content (useful for technicians) and a more management systems approach (useful for supervisors and managers). In practice, both will be needed, and the trainer is urged to develop a balanced curriculum in response to the needs of his/her audience. Any missing elements may be found in one of the other UNEP manuals, to be converted into training format based on the case studies and scenario included here.

Thus, the package is not static.

As feedback is received from users and technical specialists, the material will be modified and enriched.

Users are encouraged to report on their experiences in using this package, and to send in suggestions for improvements.

1.2 Contents of this package

This package is conceived principally to help trainers prepare a seminar, workshop, or extended course. It is not a course per se.

The package contains:

- suggestions and hints for *effective training*;
- a *short background* to the subject, drawn from other existing publications;
- *overhead transparencies* to introduce and illustrate the main ideas;
- *case studies* and situation reports and scenarios drawn from actual experience;
- *work exercises* and questions;
- *appendices* with further information about UNEP and its programmes.

Trainers are encouraged to extend the package by adding their own case studies and exercises, and expanding the subject coverage into new topics. For example, trainers in environmental health may wish to add some modules on occupational safety and ecotoxicity by building on the chemical information already presented.

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Part 2
Organizing Effective Training Activities

2 Organizing Effective Training Activities

2.1 Introduction

Communication and organizational skills are just as important as a technical appreciation of the subject. Professional educators already understand this point, but teaching is a very individual matter, and interactive teaching can be very demanding on a busy person.

Here, we recall some of the key aspects of the learning process.

This text contains suggestions about:

- *how to ensure maximum effectiveness as a trainer*
- *how to organize effective training activities and presentations.*

We have provided this advice before consideration of the technical material, so that readers can remind themselves of the importance of the advice when choosing work exercises and training projects, later in this package.

> ***Adults learn best when they are actively engaged.*** They remember 20% of what they *hear*, 40% of what they *see*, and 80% of what they *discover for themselves*.

Accordingly, this package relies on interactive teaching methods, using working exercises, case studies, and groupwork problem-solving, rather than on lecture format.

Interactive techniques are more complex to organize than simple lecture-giving, but they give better results. In particular, interactive methods are more likely to provide students with practical skills. This is important where skill development rather than factual knowledge is the objective. Lectures are better at providing factual knowledge than at developing skills.

For example, a workshop format is very effective in providing training on the effective use of management tools such as *Environmental Impact Assessment* (EIA), or audits. For high level environmental management, both knowledge and skills are required, so the appropriate mixture of techniques should be used.

The notes in this Part are based on the experiences of UNEP IE and WHO in organizing workshops and other training sessions.

Personal advice on how to be an effective trainer is also given by several experienced trainers, who all use interactive training approaches.

Notes on interactive workshop organization

2.2.1 Workshops

Workshops provide a stimulating learning environment where people with a wide range of experiences and skills can join together to address practical problems beyond the ability of an individual to resolve.

Interactive workshops use a combination of several techniques to bring about a deeper and more pragmatic learning experience than is possible with a lecture-style format.

Workshops also provide excellent opportunities for exchanging personal experiences, problem-solving through panel sessions and direct consultations with experts, and discussing some of the complex situations which surround most environmental problems.

The UNEP/WHO workshop format incorporates the following elements:

- sending out pre-workshop reading material, with some simple exercises
- preparation of a country report by each participant before the workshop
- short introductory or overview lectures on key issues
- practical problem-solving work exercises on case studies
- feedback by experts and discussions on workshop exercises
- panel sessions (that is, question-answer dialogues) with experts
- individual study sessions, computer quizzes, and so on.
- structured oral presentations of country reports leading to a regional overview
- audiovisuals such as videos, films, and slides
- field visits where appropriate
- personal action planning by participants for follow-up activity.

2.2.2 Preparation

Sessions need to be carefully prepared, with participants knowing in advance what they will do or see. A proforma report form for country reports gives a common format to these sessions. Country reports should also try to link the issues with other sessions.

It cannot be overstressed how important it is that participants should be thoroughly prepared for the workshops, and that all the pre-workshop activities have been completed.

2.2.3 Organization

The organization of working group sessions also requires care. Groups should first meet informally, elect their own chairman, and then act as a permanent team in various workshop sessions. They are guided, but not instructed, by technical experts.

It is useful to finish the workshop by preparing personal action plans. Participants should develop and present their proposals for what they can initiate immediately on their return home. Such action includes:

- what they can achieve unassisted, *and*
- what else they could achieve if some assistance were available.

The role of resource experts as advisors is crucial. They should have sufficient experience to assist in all sessions and provide general advice on all subjects in workshops, discussion or panel sessions. They should not, however, dominate the workshops.

The five day format is ideal for covering all these requirements. If less than five days is taken, you can be sure that important issues will be left out. If more time is available, consider including social events and private study sessions, along with more extensive project work for the students. A more detailed consideration of workshop organization for cleaner production in breweries follows.

2.3 A training workshop

2.3.1 Trainer's preparation

Much of the success of a workshop lies in thorough preparation, and this will inevitably be time consuming. To summarize some of the points in ***Section 2.2***, the trainer should prepare him/herself by:

- reading through the material
- working through the exercises before giving them to trainees
- planning the course and designing a detailed programme
- making/copying the preparation material for participants
- sending out the information, preparation material, and tasks to the participants in advance
- inviting people to give lectures
- preparing transparencies and course material
- planning site visits (if wanted)
- checking that all audio-visual equipment is working
- providing flipcharts and transparencies

The following pages show some sample workshop programmes and pre-workshop exercises.

The trainer should encourage participants to prepare themselves for the workshops by asking them to read the material and work through the preparation exercises sent out in advance.

2.3.2 Example of a workshop programme

It is worth reiterating that trainer preparation includes working through the exercises before the workshop and selecting materials to be used. ***Figure 2.1*** outlines a model for a training course based on this training package.

Figure 2.1 A sample training programme

	Day 1	Day 2	Day 3	Alternative Day 3
9.00 - 10.30	Introduction to Cleaner Production	*Exercise 2:* Identify environmental problems	Introduction to Occupational health and safety *Exercise 4:* OHS	• Site inspection tour • Inspection of documents
10.45 - 12.00	Interactive lesson 1	*Exercise 3:* Evaluation of problems and options	*Exercise 7:* Environmental monitoring	
LUNCH				
13.00 - 14.00	Interactive lesson 2	*Exercise 5:* Wastewater	Introduction to Environmental management	• Write environmental review reports • Discussion of the results from the site inspection tour • Course evaluation
14.30 - 16.00	*Exercise 1:* Site inspection in the brewhouse	*Exercise 6:* Water consumption	Evaluation of the training course	

Normally, a course can be divided into three levels depending on whether the participants need to:

- ***know*** what *Cleaner Production in Breweries* is
- ***understand*** the concept of *Cleaner Production Assessment* (CPA)
- ***apply*** the methodologies of CPA.

The target group and the duration of these three types of courses are shown in ***Figure 2.2***:

Figure 2.2 Target group and duration of courses

	Education level	*Target group*	*Duration of course*
A	Know	Managers	½ to 1 day
B	Understand	Middle managers and CPA team	2 to 3 days
C	Apply	Environmental managers, trainers	5 to 10 days

If you want to give a half-day introduction course, then you should focus on:

- environmental problems
- typical input/output
- occupational problems
- economic advantages of improving housekeeping levels
- legislation relevant for the brewery
- a brief introduction to the Cleaner Production methodology.

The workshop programme in ***Figure 2.1*** is aimed at middle managers or CPA team members who need to understand the idea of cleaner production, and to be able to initiate a cleaner production assessment (*'B: Understand'* in the above matrix).

During the first part of the workshop, the concept of Cleaner Production should be introduced, and some interactive sessions held. On the second and third day the participants should work through some exercises in smaller groups, and afterwards the exercises should be discussed in plenary.

A site visit to a brewery would be a good idea, but as it will take a whole day there would not be much time for the other exercises.

2.3.3 Participants' preparation

As stated earlier, it is a good idea to send out information and one or two preliminary tasks to participants before the workshop. However, time for preparation is often limited, and is most usefully spent in reading through papers.

If you send out exercises, you cannot expect everyone to have worked through them before arrival, but the more preparation that can be done, the better. It is important that preliminary exercises are simple, and aimed at demonstrating the problems or needs. *Do not use them for teaching.*

First, you could ask participants to clarify some generally used terms in a 'pre-test':

What do you understand by:	*What do you understand by:*	*What is:*
ecosystem		Cleaner Production
environmental impact assessment	Basel Convention	waste minimization
environmental audit	Agenda 21	life cycle assessment
ambient discharge standard	UNEP	material safety data sheet
environmental management system	WCSD	energy audit
ISO 14,000		waste audit

2.4 Some ideas for more effective communication

If the training is to be successful, effective communication is essential – from recognition of the training need to the final evaluation of the event.

Without good communication, all manner of things can go wrong:

- the training is too early – or too late – to make any impact on performance
- trainees do not know what the training is about or what to expect
- the course is planned for a local public holiday
- trainees who are traditionally used to lectures are suddenly required to take part in discussion groups, which might feel alien to them.

Most of these issues can be anticipated and overcome by good communication between the course designers, writers, and event organizers and presenters on the one side, and the students and their organizations on the other.

Some simple communication considerations will help to improve outputs in training and avoid disasters.

Before the learning event

Find out:

- how the learners have been taught in the past
- the real needs and situation of the learners
- whether the facilities are adequate for the envisaged training
- whether the training has the support of senior people
- how success will be measured.

Make a project plan for the organizers, giving details of how the event will be organized. Send the plan to them, with details of the key dates and needs.

During the learning

- find out how relevant the topics are to the work situation of the participants
- start with the familiar oil can – not a video of an oil spill disaster
- communicate using topics, themes and issues in the local press
- store unanswered questions, and remember to answer them before the end
- keep notes for participants to bullet-point format
- ensure the participants keep notes for future reference – few read essays, or even articles
- if you are working in a foreign language, at least translate the slides.

After the learning event

- always communicate your thanks and best wishes
- inform participants on follow-up study procedures, and how the instructor can help to analyze the evaluations and inform the organizers of the results
- communicate to colleagues the results of the training and what can be learned from these results.

2.5 Some personal suggestions for effective training

The following suggestions come from four teachers with long experience in training. They are all different in character, and therefore in teaching approaches. However, they all believe in an enthusiasm for the subject which is critical when teaching students.

To be an effective educator/teacher:

- Provide an enjoyable learning situation that expands all of the participants' network.
- Model courses and teaching styles on examples that you think are outstanding. Ask yourself about the qualities of a good instructor or a good course, and follow the answers you come up with.
- Allow the subject matter to be discussed and discovered by students – not hammered in.
- Make courses relevant and interesting by understanding your audience. Ask them what they already know, and then plan for their needs. Incorporate ideas from the group in the course.
- Remember that no amount of style will substitute for a lack of substance.

Deborah Hanlon, Environmental Scientist
Office of Environmental Engineering
and Technology Demonstration, US EPA

The outstanding educator/teacher:

- Is fully acquainted with, and believes in, the educational merit of the subject matter.
- Utilizes clear and graphic illustrations to inform and motivate the students to learn.
- Utilizes learning approaches including multi-media, projects, interviews, questionnaires, debates, and similar interactive approaches to ensure full involvement of the students.
- Reacts positively to all questions – there are no Stupid Questions, only Stupid Answers.
- Remembers that positive reinforcement is a better motivational approach than criticism.
- Is available for private discussions with individual students or groups of students.

Don Huisingh, Environmental Consultant and Professor at
Erasmus University in Rotterdam
the Netherlands

To be efficient ('doing things right'), and effective ('doing the right things'):

- Think about helping people to learn, rather than teaching them.
- Seek learner feedback, and measure learning achieved with objective tests.
- Set learning time limits.
- Seek conscious and unconscious learning.
- Seek learning that endures, based on understanding and skills.

Bob Boland, Environmental Consultant, France

The best educator/teacher:

- Likes the learners, and has a true understanding of how they learn.
- Has the ability to communicate.
- Will change the training programme and the approach if necessary.
- Is still learning, and has recent applied experience of the subject being taught.
- Has the ability to organise events and to manage things.

Colin Sutherland, Educational Consultant, France

2.6 Resource persons guide

As this package relies heavily on interactive groupwork sessions, here are some guidelines on how to be an effective resource person.

In a case study-based training approach, the resource person serves more as a:

- facilitator of the group learning process
- technical adviser as needed,

and a

- catalyst of learning

rather than a:

- lecturer
- story-teller

or

- instructor.

Here are some guidelines on how to be an effective resource person.

1 Be sure that you have ***read and understood thoroughly*** the participant's notes before you meet your group. There's nothing like being prepared and more familiar with the case study scenario than the participants are!

2 Before every group work session, take time to visit your assigned meeting room and check the:

- ***seating arrangements*** There should be a large enough table surrounded by enough chairs for the participants and yourself
- ***equipment and supplies*** such as flipcharts, flipchart papers, marker pens, white/black board, board eraser, masking tape, transparency sheets, writing pads, ballpen/pencils, calculator, etc.
- ***physical conditions of the room*** There should be sufficient lighting, the room temperature should be comfortable, noise should be as low as possible, etc.

3 During the initial group meeting, it is important to set an ***informal and friendly atmosphere***. It is suggested that you:

- ***introduce yourself***, preferably asking everyone to call you by your first name, and then let everybody introduce himself/herself in a similar manner. *Do not waste time stating positions and respective organizations, etc.,* which should have been done on the first day anyway.
- then ask if the *objectives and purpose* of the exercise, which have been previously discussed in the plenary session, are clear to them. Sample objectives are:
  - identify and understand the options that SMEs can employ in their pollution prevention program
  - evaluate the feasibility and suitability of these options in view of technical, environmental, financial, organizational, and social criteria and constraints.

It will be useful to know whether the majority of the group members have actually read the text provided, which states the background and the problem.

If they have not, then you will need to direct them to focus their attention first on what needs to be accomplished by the end of each part.

4 If your group gets involved in diverse issues, try to steer them back on the right track by ***asking relevant questions***, rather than telling them what to do.

5 Give ***technical assistance and supplementary information*** as needed,

without 'spoon-feeding' the participants. However, do not lecture or dominate the group discussion process.

6 Although you need not stay with your group for 100% of the time, it is expected that you:

- *spend at least 80% of the time* with them during regular sessions. The crucial times are at the ***beginning***, ***middle***, and near the ***end*** of each groupwork session.
- If they decide to work beyond the prescribed regular time, just make sure that they are on the right track; your presence during overtime is not mandatory, but voluntary.

7 There will be ***critical parts*** during the identification of options, followed by technical, environmental, and economic evaluation, where your technical advice will be most needed by your group.

The best way to assist the participants is by giving only the advantages and disadvantages of the options in question. Let them weigh these pros and cons and decide for themselves whether to take or drop the option.

8 If you encounter any question about the technical content of the material that you have not been briefed on, discuss it with the Team Leader and ***agree on how to tackle the situation***. It may well be that the other resource persons need to be duly advised on the particular question.

9 See to it that you ***compare notes***, ***exchange hints***, and ***share strategies*** with other resource persons so that you can assist one another, as well as gauge your group's progress in comparison with the others.

10 If tension or heated argument arises among your group members, try your best (with a sense of humor) to ***defuse*** it.

11 In the case of ***absenteeism***, approach the person/persons in question and encourage them to participate.

12 If one or two group members are dominating the discussions or doing all the work, intervene and ***encourage everyone to get involved***. In order to do this effectively, you need to be attuned to your group's 'culture' and trend of discussion.

13 Although ***division of labor*** is a time saving group work strategy, you must ensure that it is not done to the extent that there is no peer learning and discussion occurring. It is counter-productive for group members to work individually on these exercises.

14 The most productive, meaningful and fulfilling group work is when they get to accomplish what they have to do ***as a team*** – and have fun in the process!

2.7 Suggestions for self study

Although this package was designed to provide resources for trainers, the potential for self-study should not be ignored.

The package does not constitute a complete course on cleaner production in leather tanning, but can be seen as an introduction to be supplemented by further reading and additional training materials listed in the Appendices, and perhaps by site visits and discussions with professionals.

The following approach is suggested for individual study.

- Read the ***introduction***, but avoid any sections on organizing training events.
- Seek out the section containing ***background papers*** or ***subject content***. Read through the whole section as narrative.
- Work through the pages offered to the trainer for ***overhead projection***, and ensure you can relate the key points of each overhead to the text you have read.
- Look at the section on ***exercises***. Identify those which lend themselves to individual work, and tackle them. Those exercises clearly constructed for teamwork, or requiring research, may not be appropriate.
- Refer back to the ***narrative*** text as and when you need to, to complete the exercises.
- Check your ***answers*** against those given in this resource pack. Where there are discrepancies, check through your own working to understand why the discrepancies appeared.
- Use the ***Appendices*** to plan your own further development.

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Part 3
Beer Production

3 Beer Production

3.1 Introduction

The history of brewing goes back thousands of years, and has always been based on the fermentation of grains such as maize, barley and rice.
Today, beer is mostly produced from malted barley.

The malt is extracted from the barley into water. Hops are added for flavour, and the mix is then fermented with yeast to produce alcohol.

Brewing involves five major processes:

- *malting*
- *wort production*
- *fermentation and maturation*
- *filtration*
- *bottling of the beer.*

Each of these processes consists of several operations. They are all briefly described in this section.

However, the remaining parts of this training package does not consider malting processes, as they are most often carried out in separate factories. The *beer production flow diagram* included amongst the transparencies summarizes the whole process, and Figure 3.1 in this section gives a more detailed, general summary of the process.

A more extensive discussion of the brewing process is found in the UNEP Technical Report attached to this package, and in the references in that report.

3.1.1 Malt production

The purpose of malting is to prepare the starch in the barley for easy degradation during mashing, whereby it is transferred into easily fermentable sugar. Furthermore, the malting and drying gives taste and colour to the beer.

After delivery in bags or bulk containers, the incoming barley is cleaned and graded. Foreign particles such as grit, weed, seed, as well as grain with a diameter of less than 2.2mm, are removed. Together with the skimmings, these are used for chicken feed.

The cleaned, graded barley is stored in silos, and transferred from there into the steep tanks. The first steeping water, which is also used for washing the barley, is run into the sewage system. Steeping is continued until the barley has reached a moisture content that allows germination to start up. This occurs normally after three days.

The steeped batch is transferred into the germination box. Rootlets and spires grow until they have reached two-thirds to three-quarters of the length of the grain.

When enough enzymes have been built up (normally after seven days), the germinating process is interrupted. Then the green malt is brought into the kiln for curing. Kilning usually lasts about 20 hours. The germinating box is cleaned using high pressure cleaning devices, and the wastewater is run into the sewage system.

The prepared malt is polished to separate the rootlets and then the malt is stored in silos awaiting delivery to a brewery. Because of their high concentration in proteins, the rootlets are used as animal feed.

3.1.2 Wort production

The remaining stages in the production process can be followed on ***Figure 3.1***.

The malt is delivered to the brewery in bags or bulk containers, transported by conveyors, and stored in silos. From here, it is transported by separate conveyors (via a polishing device), into a one-brew blending silo. On its way, it passes a permanent magnet and a scale, before being ground in a malt mill.

The ground malt is collected in a grist bin or a hopper before being mixed with water in a pre-masher during the mashing process. The mash is heated to a high temperature in the mash-tun to activate the enzymes built up during malting.

The next step is the separation of the grist residues. This takes place at the lauter tun.

When the first wort (the extract from the water and the malt) is separated, the remaining extract is washed out of the spent grains by spargings: that is, spraying hot water over the grains. The last extract (last runnings) are used in the mashing of the next brew. The spent grains are used as animal feed.

The wort is brought into the pre-run vessel and then to the wort kettle, where it is boiled together with the hops. During the boiling, proteinous substances coagulate and fall out, together with hop residues and tannins.

The so-called trub – also named hot break – is separated from the wort in the whirlpool (which has a tangential inlet), circulating the whole inflowing batch at speed. The result is that the hot break settles like a cone at the bottom of the whirlpool about 25 minutes after wort pumping is finished.

The hot break is collected and pumped back into the lauter tun to be added to the next brew.

The wort is cooled down from its 95°C to approximately 8°C in a heat exchanger (a wort chiller), transferred into the gauging vessels, and then passed to the fermenters.

Wort cooling produces hot water, which is normally returned to a hot water tank in the brewhouse and used for brewing/spargings and for cleaning. All vessels and pipes in the brew house are cleaned using the CIP (Cleaning-in-Place) system.

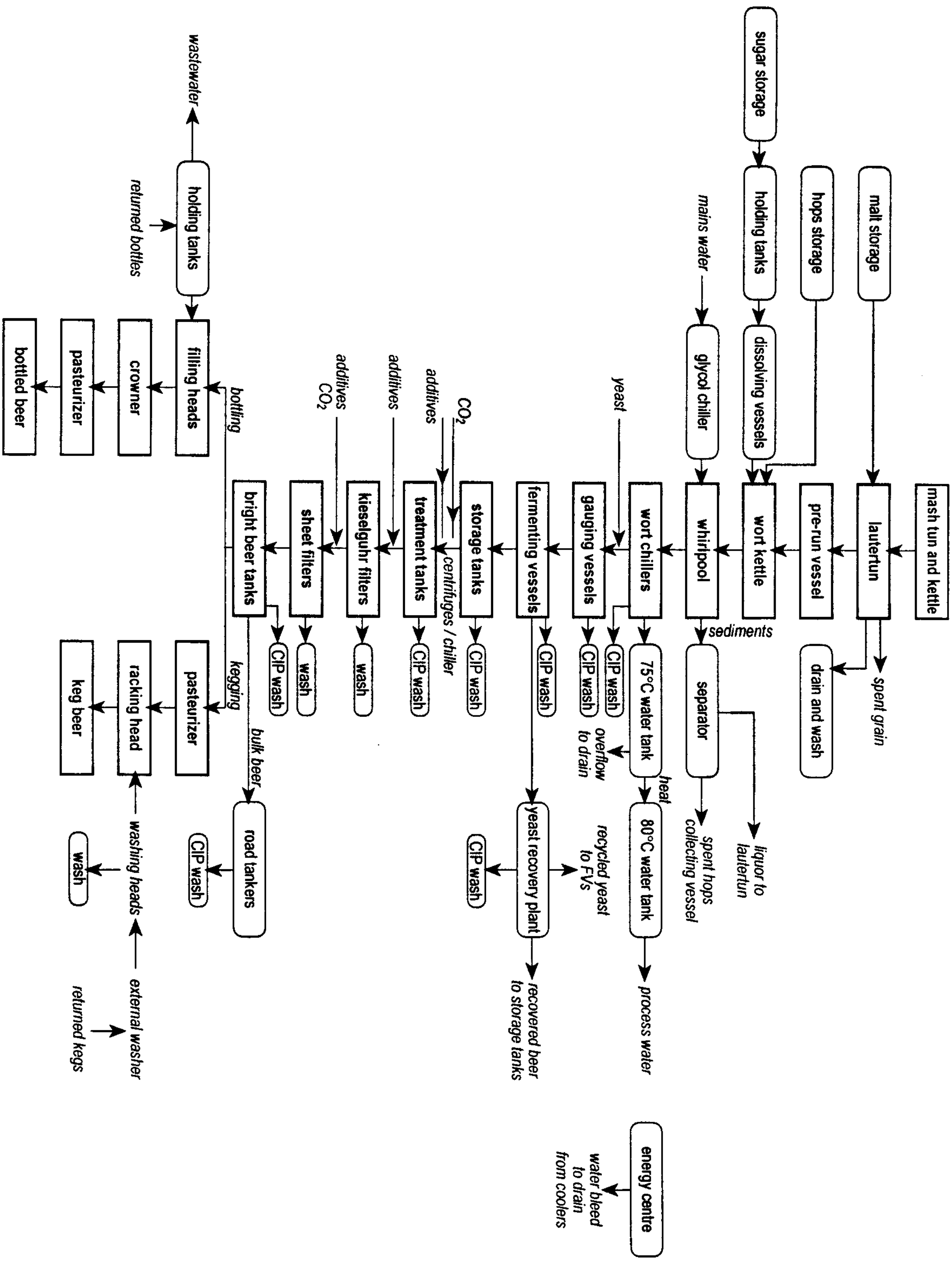
3.1.3 Fermentation

The cooled wort is aerated, yeast pitched by a metering pump, and fermentation is started in the conical fermenters. Fermentation normally takes seven days.

During fermentation, the yeast settles in the cone of the fermenter. The most active yeast is taken out of the fermenter for re-utilization in another batch. As the yeast is multiplied by approximately six or seven times, there is a considerable amount of excess yeast from each fermenter. The surplus yeast has widespread uses, from animal feed to pharmaceutical purposes, but can also be discharged to the sewer.

When the main fermentation is finished, the green beer is pumped into storage tanks for maturation. During the maturation, a second fermentation takes place under high pressure, building up dissolved carbon dioxide in the beer, while the remaining yeast settles out. This deposit yeast is used for animal feed or is discharged. The maturation can also take place in an unitank, which is used for both primary fermentation and maturation.

Figure 3.1 A general flow diagram for a brewery



3.1.4 Filtration

The finished beer is prepared for bottling or kegging by filtration and addition of carbon dioxide. To ensure a standard quality, some batches of beer are blended and colour may be added.

Before filtration, the beer is cooled down to 0-1°C to minimise the risk of it foaming in the filters. The beer is normally filtered in a coarse filter and a fine filter. To avoid too high a filter resistance, kieselguhr is used as a filter medium.

Modern breweries use pressure leaf or candle filters for coarse filtration. By using kettle filters for coarse filtration, it is also possible to bring out the wasted kieselguhr in a pasty consistency for separate collection, thus avoiding loading up the effluent.

The filtered beer is pumped into a bright beer tank and is stored there until it is needed in the bottling hall. The bright beer tanks are cleaned by CIP.

3.1.5 Bottling

The beer is bottled under counter pressure and the bottles are sealed. A spraying device takes foam residues away. After passing a fill height inspector, the bottled beer is pasteurized, labelled and packed.

The bottles (new or returned) are passed through the bottle washer for cleaning. The bottles are alternately soaked and sprayed in the washer; first with warm water, then with a hot caustic solution, thirdly sprayed and rinsed in hot and cold water, and finally a last cold rinse before they are conveyed to the bottling machine.

In the case of empty kegs, the cleaning process is similar, except the kegs are not soaked.

The caustic solution needs to be replaced after the lye solution is exhausted. Often, it is merely dumped, without treatment, into the sewage. The water in the bottle washer is circulated several times before being used in the soaking bath.

After bottling, the beer goes to the pasteurizer. The bottles pass slowly through different zones with increasingly hot water (up to 62°C), and then slowly cooled down to approximately 25°C. The water in the tunnel pasteurizers is circulated and thus used repeatedly. Any breakage is normally collected in containers and returned to the glass manufacturers for recycling.

3.2 Case study: a brewery in East Africa

The following case study originates from a three-month environmental study at a brewery in East Africa. Although an actual situation, the trainer can treat it as a generic case study to allow realistic problem-solving exercises to be developed. Many of the exercises, especially those in Part 6, are designed around this case study. If trainers have their own case studies based on local experience, they should consider adapting exercises to those, perhaps using the format in this guide as a template.

The study was carried out by Anna Levin-Jensen and Bent N. Hummelmose in co-operation with the company management and employees.

This description includes physical layout, organization set-up, overall production processes and main inputs and outputs.

Read the following description in conjunction with the site plan (***Figure 3.2***), and the simplified production flow diagram for the brewery (***Figure 3.3***). ***Figure 3.3*** will also be useful for some of the exercises in Part 6 of this package.

3.2.1 A short description of the brewery

On entering the main gate, the ***engine rooms*** and the ***brew house*** are to the left, while the ***parking lot*** and the two ***administration blocks*** are straight ahead. The ***new brew house***, built in 1982, is a stainless steel 400hl unit, and is placed in a cramped room next to the old 100hl brew house. The ***whirlpools*** and the ***wort cooler*** are separate, in a room next to the workshops.

The wort is collected in ***fermentation room no. 3*** (the collection room), before being transferred to one of the 22 unitanks. Each unitank has a capacity of 1200hl and a head space of 400hl.

The ***beer processing room*** next to the unitank farm is big and cold. It has a filter and five 400hl bright beer tanks. A twisting passage runs from the brew house to the unitank farm and the beer processing room through the old fermentation cellars.

The ***bottling hall*** is a two-storey building, with storage for empty and full crates on the ground floor, and the bottling line on the first floor. There is only one bottling line in the bottling hall, even though there is room enough for three lines.

The capacity of the bottling line is 1152 crates (28 800 bottles) per hour. Due to problems with machinery and utilities, production is normally about half of this.

3.2.2 Organization

The brewery is organized hierarchically, with the Plant Manager at the top, with eleven Department Managers below him.

Top management meets daily at 10.00am to discuss problems and production in general.

The eleven departments are engineering, brewing, packaging, quality control, supply, distribution, transportation, personal administration, accounting, security, and the workshop.

The employees in the *engineering* and *brewing* departments work three shifts:

6am to 2pm; 2pm to 10pm; 10pm to 6am.

In the *packaging* department, the employees work two shifts:

6am to 2pm; 2pm to 10pm.

Figure 3.2 A plan of the brewery

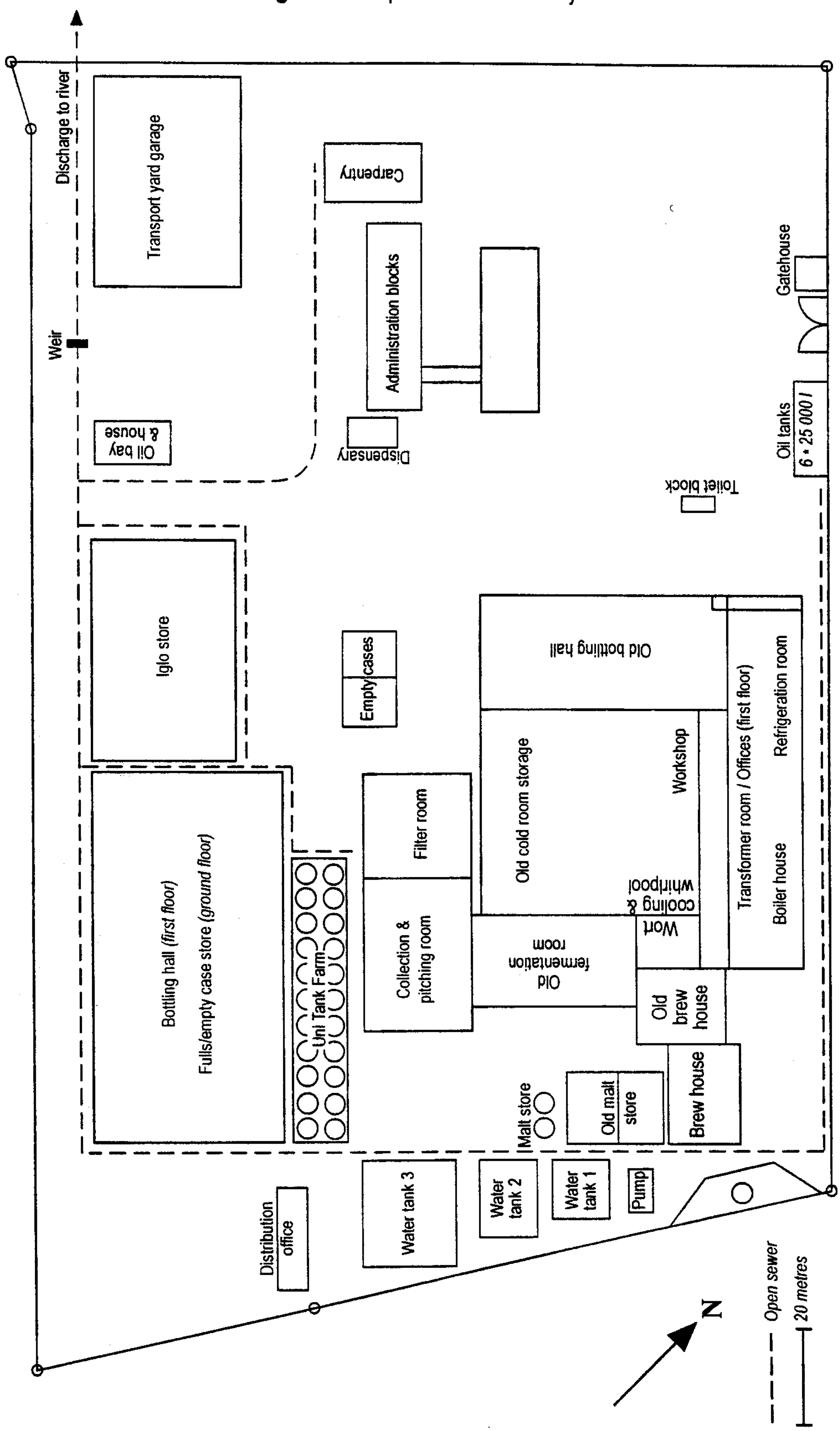
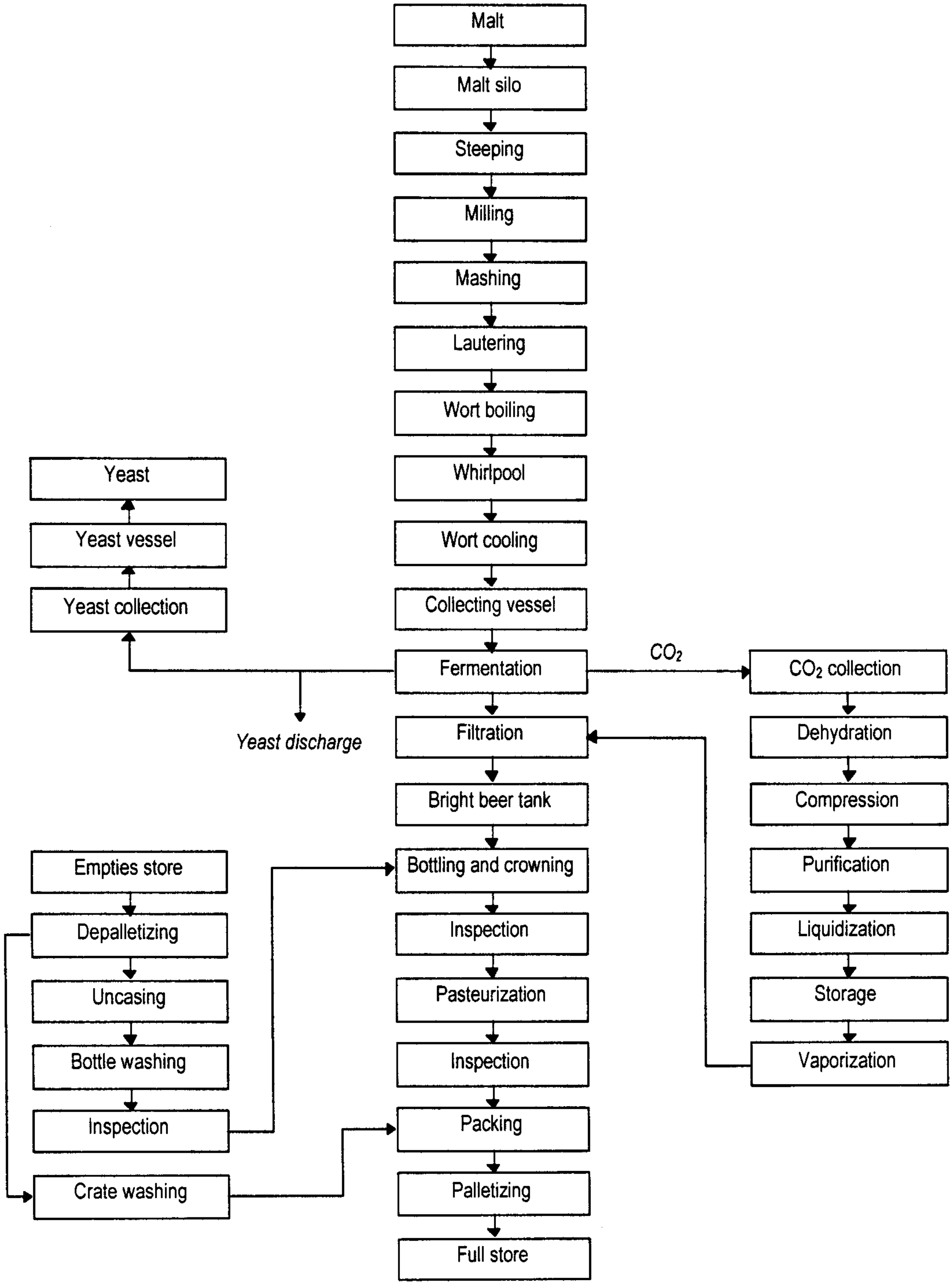


Figure 3.3 A production flow diagram for the brewery

This diagram includes processes for recovery of CO_2 and for cleaning of bottles, but not for malt production.



3.2.3 The production processes

Brewing is based on the standard four processes of:

- ***wort production***
- ***fermentation and maturation***
- ***beer processing***
- ***bottling.***

Malt is either produced at another factory or imported from Europe.

Wort is produced in the new 400hl brew house. The process takes about ten hours, from when the malt is pumped into the malt hopper until the cold wort is received in the collection vessel. It is possible to make between three and five brews every day on a 24-hour basis.

The brewing ingredients are malt, sugar and hops. Sugar is used instead of cereals because it is cheaper. The sugar is added to the wort kettle while the wort is boiling. Briefly, the process in the brew house is:

- ***steeping*** the malt before milling
- ***mashing*** in the mash tun
- ***filtering*** in the lauter tun
- ***boiling*** in the wort kettle, where hops and sugar are added
- ***settling*** in the whirlpool
- ***cooling*** down to 10°C in the wort cooler.

The wort is collected in the 400hl collection vessels where yeast is pitched and air injected. The fermentation and maturation process, which happens in the unitanks, takes only about three weeks, as modern process technology is used. After the primary fermentation, yeast is harvested for reuse or discharged into the sewer.

When the beer is ready for filtration, the cold green beer is transferred to the beer processing room. There it is filtered in a coarse filter and in a polishing filter, using filter sheets and kieselguhr. After filtration, the beer is cooled and carbon dioxide is injected. The bright beer is stored in one of the bright beer tanks until it is transferred to the bottling hall.

The bottles are conveyed to the unpacker and then to the bottle washer. After inspection, the beer is bottled in brown, half litre bottles, and the bottles are crowned and pasteurized in the tunnel pasteurizer. The bottles are labelled and packed in 25 bottle crates, then conveyed to the fulls store where the crates are manually palletized.

3.2.4 Inputs and outputs

For both environmental and economic reasons, it is important to know the total consumption data as well as the consumption per produced beer.

It is particularly important for environmental reasons to know, for instance, how much wastewater is discharged and the organic load of the wastewater.

The main ***inputs*** at the brewery are:

- *fuel oil for steam generation*
- *electricity*
- *water for beer production and cleaning.*

The main ***outputs*** are:

- *bottled beer*
- *wastewater to the sewer*
- *emissions to the air, mainly from the fuel combustion.*

The monthly consumption and production figures are stated in ***Table 3.1*** and ***Table 3.2***.

To evaluate the economical effects of cleaner production options, prices on different materials and resources were collected. There were no discharge costs for discharging wastewater to the river, and only symbolic payment for disposal of solid waste. Costs are listed in ***Table 3.3***.

Table 3.1 Monthly consumption figures for 1993

Material consumption	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wort production												
Malt *(kg)*	338640	337640	314510	212580	256260	259160	254320	310490	400290	335800	332200	393100
Sugar *(kg)*	96800	92550	97050	67600	70800	70750	74500	89300	99000	62850	77100	94300
Hop pellets/extract *(kg)*	1303.5	1133.6	974.7	735.3	976.8	1047.9	975.6	1162.8	1437.3	1222.4	1185.3	1418.7
Beer filtration												
Filter sheets *(pieces)*	215	445	180	318	161	316	412	303	571	392	318	249
Filter powder *(kg)*	4825	6680	6935	3840	5375	6220	6950	10405	14930	10325	8170	8780
Resources												
Oil *(m^3)*	187.1	179.3	181.5	126.1	141.1	172.8	153.6	172.8	215.4	189.3	189.5	205.3
Oil *(MWh equivalent)*	1644	1576	1595	1108	1240	1519	1350	1513	1893	1664	1666	1805
Electricity *(MWh)*	387	353	340	158	313	293	291	289	325	355	340	376
Total energy *(MWh)*	2031	1929	1935	1266	1553	1812	1641	1802	2218	2019	2006	2181
Spirits *(l)*	1200	1200	800	800	1000	600	800	800	1200	800	800	1000
Ammonia *(kg)*	128	192	256	0	320	128	64	128	128	192	256	520
Chloride of lime *(kg)*	200	100	150	0	60	150	150	150	150	150	200	150
Water, partly *(m^3)*	29628	50396	48552	19088	42120	40419	25369	–	24173	21301	–	–
Freon, CFC-12 *(kg)*	–	–	–	–	–	–	–	–	–	–	–	65
Caustic soda *(kg)*	12900	10685	12300	7600	11700	12600	10400	11250	12000	10600	9800	12740

Table 3.2 Monthly production figures for 1993

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wort production												
Total *(hl)*	23745	24704	23257	15811	18761	20655	18561	22591	27840	22024	23086	27441
Bottling												
Total *(cases)*	185131	173767	176082	95811	120667	134952	133344	124983	173112	162708	142714	194332
Total *(hl)*	23141	21721	22010	11976	15083	16869	16668	15623	21639	20339	17839	24292
Bulk beer losses												
Total *(hl)*	1230	1056	1397	1231	2083	1281	2240	2781	3514	2489	2395	2644
% of bottled beer	6.45%	5.82%	7.25%	12.33%	16.76%	9.07%	16.38%	20.78%	18.60%	14.77%	15.69%	12.76%
Bottling losses												
Total *(hl)*	770	664	688	269	362	433	341	629	1147	387	826	666
% of bottled beer	4.04%	3.66%	3.57%	2.69%	2.92%	3.06%	2.49%	4.70%	6.07%	2.29%	5.41%	3.21%
Bottle amortization												
Cases	5469	4397	2471	1349	1608	1600	1702	1676	2636	1649	1551	1902
% of total handled	3.22%	2.38%	1.52%	1.59%	1.49%	1.36%	1.40%	1.52%	1.63%	1.13%	1.15%	1.11%

Table 3.3 Prices for selected resources and materials in US$ [1994]

Resources and materials		Price per unit *(in US$)*
Fuel oil	*(l)*	0.23
Electricity	*(kWh)*	not available
Water	*(m^3)*	0.20
Malt		0.39
Sugar		0.37
Hop pellets and extract (average price)	*(kg)*	15.00
Filter sheets	*(per piece)*	8.00
Filter powder	*(kg)*	0.20
Spirits (for cooling)	*(l)*	1.10
Ammonia	*(kg)*	2.75
Freon, CFC-12	*(kg)*	8.20
Caustic soda (dry form)	*(kg)*	2.00

3.2.5 Inputs

Water

It is not possible to tell exactly how much water is used at the brewery, as only one of the flow meters were in order in 1993. Instead of paying according to the actual consumption, the brewery pays for a fixed amount of water every month: 75 586m^3. The price of water is approximately 0.2US$ per cubic metre.

Compared to beer production, water consumption is very high. A well maintained and well run brewery with the same equipment should use 10-12 litres of water per litre of beer which is bottled.

This high water consumption is due to leaks, dripping or running valves, high consumption of water during cleaning, and the water used in the bottling hall.

The main areas for action are:

- *cleaning*
- *bottle washing*
- *pasteurizing.*

Oil

The fuel oil is used for heating up water to 6-7 bars steam, which is mainly used in the brew house and in the bottling hall. Steam is, however, used in every department for cleaning and sterilization.

The figures in ***Table 3.1*** indicate a high consumption of fuel oil. This is due to leaks in the steam pipes and valves, especially in the brew house and in the bottling hall. The insulation is also incomplete or degraded many places.

Steam losses equal energy losses (from the unnecessary use of oil). It is, however, difficult to estimate the steam losses, because there are many small leaks throughout the whole system, and there is no measurement of steam generation.

Electricity

The consumption of electricity is high compared to European breweries, where the electricity consumption on average is 11.6kWh per hl of beer. The potential for saving is high.

3.2.6 Outputs

Production

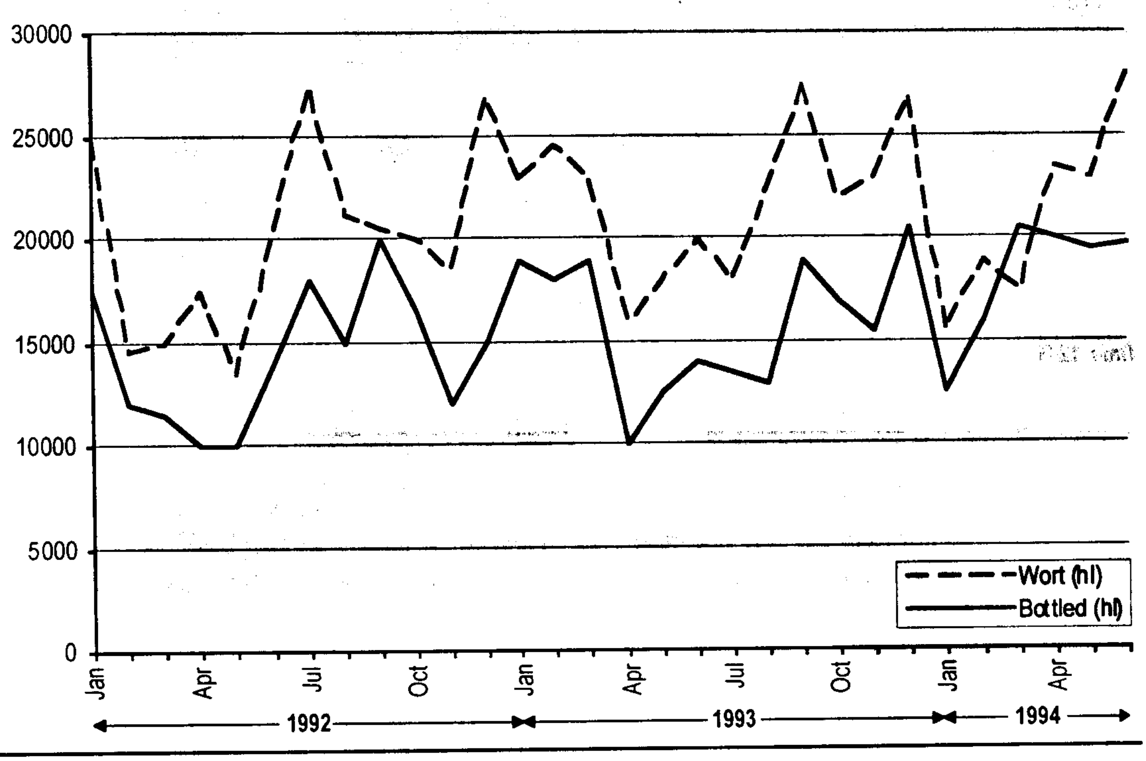
There are three ways of measuring production in a brewery. The most obvious is the amount of beer bottled. For internal evaluation, the amount of wort produced and the amount of beer filtered are also significant. The production figures for 1993 are given in ***Table 3.2***.

The amount of wort produced is always higher than the amount of beer filtered and bottled because of losses during the production. ***Figure 3.4*** shows the monthly production since January 1992. The production varies throughout the year; the reasons being:

- lack of empty bottles
- no carbon dioxide
- power cuts
- major breakdowns.

It is worth noting that the actual production is much lower than the designed capacity of the brewery, which is 500,000 hl beer per year.

Figure 3.4 Production of wort and bottled beer



Wastewater

There are two sewer systems at the brewery. One is a *closed* system, to which all toilets and kitchens are connected, and the other is an *open channel* sewer, where all process wastewater is discharged. The process wastewater is led through the sewers to the main sewer channel (the only factory outlet for process wastewater).

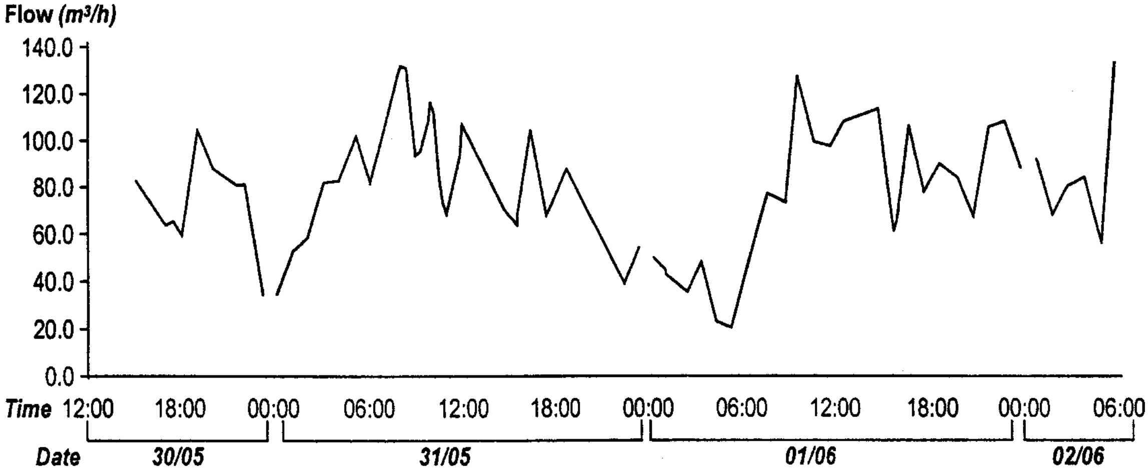
The main closed sewer continues to its outlet in the river. The outlet is close to where residents wash clothes and utensils.

Wastewater flow

To measure the wastewater discharge, a rectangular, thin-plate weir was made and installed according to the standard ISO 1438 (see also p.106 in UNEP/UNIDO's *Audit and Reduction Manual for Industrial Emissions and Wastes*, Technical Report Series No 7). The water flow was determined by reading the water level on a staff gauge and then calculating the flow in cubic metres per hour. The calculated flow was checked by measuring the time to fill up a bucket at the overshot. The flow measurements were taken several times from May to June 1994.

The fluctuation of the amount of wastewater during the day is very high due to the batch operation of brewing. ***Figure 3.5*** outlines the fluctuation during one period of measurements. The hourly variation of the wastewater can range to between two and three times the average.

Figure 3.5 Flow measurements in the main sewer *from Monday afternoon until Thursday morning*



From the measurement at the weir, the discharge from Monday to Friday was calculated to be 76m^3/h, and 46m^3/h during weekends. Much water is discharged during the weekly cleaning on Saturdays, but the water discharge on Sundays mainly originates from leaks and open valves. At the beginning of measurement period, a huge leak from an outside water pipeline affected the flow in the sewer. This was later repaired.

Wastewater is a serious environmental problem for four main reasons:

- the amount of wastewater is very high
- the organic load is high
- the average temperature is more than 30°C
- the pH is high.

COD in the wastewater

Measurements gave an average COD loading in the sewer of 2.8g COD/l.

The minimum and maximum values measured were 0.6g COD/l and 8.2g COD/l. The concentration of 2.8g COD/l is much higher than the limit set by the municipality (30mg BOD/l).

The BOD/COD ratio for brewery wastewater is 1:1.8-2.0. The organic load from the brewery is high compared to other breweries, because it discharges all excess yeast, and has high beer losses.

Wastewater temperature

The temperature varied from 18°C to 54°C, an average of 32°C.

The high temperature is mainly due to:
- the sterilization of equipment and mains
- the high temperature of discharged pasteurization water
- hot water from the bottle washer
- discharge of some condensate return from the brew house and the bottling hall.

Wastewater pH

Measurements of pH were taken in small samples from the sewer. The pH in the wastewater ranged between 6.4 and 12.3, but most of the pH values were around 9-10. Most brewery wastewater is alkaline as caustic soda is used for most cleaning purposes, including equipment and bottles. The discharge of used caustic occurs after the cleaning of the unitanks and bright beer tanks, and from the bottle washer throughout the week. The bottle washer is often topped up with caustic, and – due to overfilling – the pH level increases in the main sewer. During weekends, caustic is used for cleaning everywhere, and discharged the same day.

Air emissions

Air emissions come mainly from boilers and wort boiling. The combustion of fuel oil gives 40.2MJ/kg or 39.6MJ/l; however, the typical efficiency of boilers is 90%, and therefore only 35.6MJ/l is gained. Fuel oil in Denmark is allowed to contain 1% sulphur by weight, but typical sulphur concentrations are 3-5$^{w}/_{w}$-% sulphur and 1-1.5$^{w}/_{w}$-% for low sulphur fuel oil. Emissions from combustion of fuel oil with different levels of sulphur are listed in ***Table 3.4***.

Table 3.4 Emissions from combustion of 1000 l oil

Type of oil	Sulphur $^{w}/_{w}$-%	SO_2 (kg)	NO_x as NO_2 (kg)	CO_2 (kg)
Fuel oil	1	19	5.4	2664
Fuel oil	2	38	5.4	2664
Fuel oil	4	75	5.4	2664
Gas oil	0.2	3	3.6	2664

3.2.7 Detailed description of wort production

The brewhouse, dating from 1982, has a capacity of 400hl. It is in a cramped room, and is rather run down. The whirlpool and the wort cooler are in a separate room nearby. The wort is collected in a collection vessel before being transferred to one of the unitanks. Many steam pipes and valves leak in the brewhouse, which is a hazard for the workers.

The brewhouse's equipment is listed in ***Table 3.5***.

Table 3.5 Equipment used in the brewhouse

	Equipment	Capacity
2	malt silos	2 x 300 tonnes
1	malt weight	50 kg/tip
1	wooden malt hopper	6000 tonnes
1	adjunct hopper	not in use
1	stratification tank	about 1000 hl
1	maschiomat hopper and mill	6000 tonnes
1	mash kettle	220 hl
1	mash tun	350 hl
1	lauter tun	400 hl
1	trub vessel on top of lauter tan	30 hl
1	wort receiver	490 hl
1	wort kettle	600 hl
1	whirlpool	400 hl
1	wort cooler	400 hl in 1 hour
	CIP cleaning system	out of order

The wort production process takes about ten hours, from the malt being pumped into the malt hopper through to the cold wort being received in the collection vessel. It is possible to brew three to five brews every day on a 24-hour basis.

The production takes place from Monday to Friday, and cleaning is done on Saturdays.

The process is as follows.

Malt is transferred from the store to the malt hopper, and steeped in hot water before milling in the Maschiomat. From the Maschiomat, the milled malt is transferred to the mash tun. The mash is then heated in the mash tun to different temperature levels at different time intervals, allowing the mash to rest in between. Infusion mashing is used.

In the lauter tun, the extract and spent grains are separated. About 170hl of sparging water is added during three spargings, producing 410hl of wort. The spent grains are conveyed and boosted with compressed air or steam to the spent grains container outside the brewhouse.

From the lauter tun, the wort is pumped to the wort kettle where sugar and hops are added. The sugar is carried up to the warm, dusty room in 50kg bags, and is poured manually through a hopper from the first floor. The hops are added through a manhole above the wort kettle. The ladder which provides access is unsafe.

In the wort kettle, about 10% of the wort is evaporated during the 90 minutes boiling time.

From there, the wort is transferred to the whirlpool, and rests for 30 minutes before the hot break (trub) is separated from the wort (extract). The hot break is discharged to the sewer, and the wort is cooled in the wort cooler, and transferred to a collection vessel. The wort cooler is a counter-current plate cooler, in which the wort temperature drops to 35°C. The second part of the cooler uses spirit to bring the wort temperature down to 10°C. The hot/warm water from the wort cooling is returned to the stratification tank, if it is not already full.

Often, there is insufficient hot water for mashing. To compensate for this, steam is used to heat the water in the stratification tank which then makes it too full to receive the water from the wort cooling.

Weekly cleaning

The brewhouse equipment and the whirlpool room are cleaned weekly. About 170hl of water and 200kg of caustic are mixed and boiled in the mash tun.

The caustic is handled manually, and the worker does not have protection equipment.

The lye is pumped in to the lauter tun and the pre-run vessel. When it enters the wort kettle, more caustic is added and the lye boils for almost an hour. The boiling lye solution is pumped to the whirlpool, from where it passes through the heat exchanger and the pipes to the collection vessels. The lye is then pumped around most of the green beer mains, until it is discharged onto the floor to clean it. To rinse out the lye, water is boiled and pumped through the same vessels and pipes as the lye. The hot water is followed by two batches of warm/cold water.

The wort kettle is cleaned after every third brew to maintain its heating efficiency. Cakes of hop and sugar are partly removed manually, partly by the use of a hot caustic solution heated in the wort kettle. The Maschiomat is only rinsed once a month with a 5% lye solution. Maintenance is undertaken on Saturdays, and on Sundays if necessary, after the cleaning has finished.

3.2.8 Detailed description of fermentation

The fermentation section consists of the collection rooms for wort and yeast, and the unitank farm. The equipment used is listed in ***Table 3.6.*** There are six vessels in the collection room, but only two are used for collection and pitching of wort. The rest are used for propagating yeast, as the propagation vessel is out of order (propagating yeast: producing new yeast for pitching).

The main cleaning is done every weekend, just like in the brewhouse, and hot caustic from the brewhouse is circulated in the beer mains.

The collection vessels are cleaned after use, and so are the unitanks.

Table 3.6 Equipment used in fermentation

Equipment		*Capacity*
2	collection vessels	*2 x 400 hl*
22	unitanks	*22 x 1200 hl*
1	cleaning pump	
2	cleaning vessels	
1	yeast pump	
6	yeast tubs	*6 x 800 l*
	yeast propagation vessel	*out of order*

Process description

The wort is pumped from the wort cooler and collected at 10°C in the collection vessel, where it is aerated and pitched with yeast. The pitching rate is approximately 1kg yeast/hl wort ($10\text{-}12 \cdot 10^6$ cells/ml).

After pitching, the wort and yeast slurry is agitated with sterile air to ensure good mixing and sufficient air to allow the yeast to grow and complete the fermentation. During the collection of the wort, samples are taken to control the gravity and the level of micro-organisms.

When the pitching is complete, the wort is allowed to rest so that the cold trub settles. Afterwards, the pitched wort is transferred to one of the unitanks. When one unitank is full (that is, when three brews have been collected, pitched and aerated), the fermentation can begin. The fermentation process lasts for about 21 days before the green beer is filtered. During fermentation, sugar is converted to alcohol.

After about two days, the first yeast harvest takes place. Only the thick yeast – around 1 600kg – is removed from the unitank. The yeast is sampled to check cell number and viability, in case it is needed for reuse. The second and third yeast harvests are normally done two and four days respectively after the first harvest. The harvested yeast is transferred to a yeast tub where it is stored until the next pitching. If there is sufficient yeast for pitching, the rest of the harvested yeast is discharged directly to the sewer. The yeast is only reused about six or seven, times after which it is propagated afresh.

When the desired gravity (strength of alcohol) is reached, the temperature is raised to 13°C for about ten days. The beer maturates during this time. Four days before filtration, the green beer is cooled down to 0°C, to enhance the settlement of solids and yeast remains.

The environmental problems in the fermentation area are mainly concerned with water and resource consumption. As the wort is collected in a collection vessel before transferral to a unitank, more water, detergent and energy are used than if the collection vessel were omitted. When sterilizing the beer mains, excess water and steam are used, and it should also be possible to reduce the amount water used for cleaning one unitank.

Finally, one of the major environmental problems at the brewery is the discharge of excess yeast into the river.

Every weekend, when the main cleaning is done, hot caustic is circulated from the brewhouse to the unitank farm. About 290hl of hot water containing approximately 100kg caustic is discharged onto the floor. The floor becomes slippery and the room gets very steamy. The fumes contain caustic, and thus constitute a serious health risk.

3.2.9 Detailed description of filtration

The beer processing room consists of a filtration unit, and the equipment used is listed in ***Table 3.7.***

The green beer is transferred from the unitank farm. Prior to filtration, a kieselguhr slurry is injected in the beer to facilitate the removal of remaining yeast and suspended solids. The beer is sometimes recirculated until there is no haze.

Next, the beer is filtered, first through a coarse filter and then through a polishing filter.

The speed of filtration varies with the filterability of the beer, but is between 100-240hl per hour. The filter is backwashed when the filter resistance is too high. The filter is opened and the filter cake is removed with water. The filter is assembled and pre-coated again before the filtration can proceed.

After filtration, the green beer is cooled to 0°C, carbon dioxide is added, and the beer is stored in the bright beer tanks until it is ready for the bottling hall.

Just like in the brewhouse and the fermentation section, cleaning of the filtration room is done on Saturdays. The hot caustic from the brewhouse is circulated in the beer mains in the beer processing room. However, the bright beer tanks are cleaned every time they have been emptied, and the floor is cleaned every day. The BBTs are cleaned with water and caustic, and are checked daily for any infections.

There are two environmental problems concerned with the beer processing room, both related to the backwashing of the filter. The kieselguhr slurry mixed with yeast is washed out to the sewer and the consumption of water is high.

The other problem relates to energy consumption. The beer processing room is big, and the whole room is air-cooled. The temperature is constantly around 11-14°C, which is very cold for those working there for several hours. The workers sometimes uses hot steam to warm themselves.

Table 3.7 Equipment used in filtration

	Equipment	Capacity
	pre-coat dosing tank	
	filter I & II (coarse and polishing filter)	
	cooler	
	carbonator	
5	bright beer tanks	5 x 400 hl
	filter for waste beer	
2	waste beer tanks	2 x 80 hl
	room coolers: temperature regulated	
	cleaning recirculating pump	

3.2.10 Detailed description of bottling

The equipment used in the packaging department is listed in ***Table 3.8***. The packaging department delivers pasteurised bottled bright beer in cases, with 25 half-litre bottles in each case.

There is one shift supervisor on each shift, and one extra to cover for illness or holidays. At each shift, 48 workers work at the various machines. Bottle inspection is done manually by job rotation, moving from the cleaned, empty bottles to the full bottles. Palletizing and depalletizing is also done manually; here, the shift has been increased to provide relief. Four people work for one hour depalletizing or palletizing, and then rest one hour.

The return bottles and cases enter the bottling hall from the empties store on the ground floor; the bottling hall is on the first floor. When the crates arrive at the brewery, they are manually unloaded from the trucks and palletized. After unloading, the pallets are brought to the store, where the crates are manually depalletized. The crates with bottles are then conveyed to the unpacker. From here, the bottles are conveyed to the bottle washer and the empty crates to the crate washer, and from there on to the packer.

The bottles are soaked, washed and rinsed for about 30 minutes before they are inspected manually. After inspection, the bottles are filled, crowned and conveyed to the pasteurizer. Before arrival at the pasteurizer, defective bottles (with head space too big) are removed; any bottle that is not filled or crowned properly is picked out and returned to the waste beer tank. From here, the waste beer is discharged to the sewer.

Table 3.8 Equipment used in packaging

depalletizer: *not operating*	crate washer
unpacker	packer
bottle washer	palletizer: *not operating*
filler and crowner	crate conveyors
pasteurizer	bottle conveyors
labeller	

The pasteurization process takes 30 minutes, in different temperature zones. After pasteurization, filled bottles are inspected. The last process before the bottles are packed is labelling. Approximately half of the bottles are not labelled, because one of the two labellers is malfunctioning.

From the packer, the filled crates are conveyed to the ground floor where they are palletized manually. A forklift puts the pallets into storage before distribution.

The bottle washer causes several environmental problems:

- it has a high consumption of caustic
- the condensate return is not used due to leaks, and risk of caustic in the boiler
- the bottle washer is leaking rinsewater.

In addition, waste beer is discharged to the sewer, thus causing high amounts of organic matter to be discharged to the river. The filler and crowner uses a lot of water to remove foam and flush away glass cullets. The crate washer also uses large volumes of water, and none of it is reused. The water and steam consumption in the pasteurizer is high, resulting in a poor energy balance. Finally, too much lubrication soap is used on the conveyors.

There are a number of working environmental problems in the packaging department, many of which concern physical hazards: such as glass cuts from exploding bottles, poor conditions for bottle inspectors, and manually depalletizing and palletizing of cases. The noise level in the bottling hall is very high.

You will be aware that a number of Cleaner Production issues have been highlighted in this case study, but the solutions have not been given.

General approaches to solving Cleaner Production issues are highlighted in the transparencies. As you look through the transparencies, constantly refer back in order to match the solution to the problem.

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Part 4
Transparencies

4 Transparencies

The transparencies on the following pages are designed to:

- give a brief introduction to Cleaner Production in breweries,
- highlight some of the key environmental problems in breweries.

Further useful transparencies will be found in UNEP's training resource package *Cleaner Production*, which gives broader cover of the concepts and practices of cleaner production.

Trainers are encouraged to augment the transparencies provided with those of their own. Tables and figures in the text are an obvious source of such transparencies.

The following pages include transparencies on:

- Cleaner Production (in general)
- environmental management systems
- waste audit/energy audit procedures
- Cleaner Production in breweries
- flow diagram for beer production
- typical resource consumption figures for breweries
- typical waste problems in breweries
- occupational Health and Safety problems
- legal requirements.

Space is reserved under each transparency for the trainer to note important information and speaking points.

What is Cleaner Production in Breweries?

Principle	*Example*
Good housekeeping	Reduce resource consumption by maintenance of equipment
Process optimization	Ensure evaporation in wort boiler is optimal, to avoid waste of energy
Substitution of materials	Use ammonia coolers instead of freon
On-site recycling	Reuse cleaning water for site cleaning and bottle washing
New processes	Membrane filtration of beer instead of kieselguhr filtration

Observations: only a few examples are given above. The trainer should find their own examples, or ask trainees to make suggestions.

What can we do?

Implement a Cleaner Production programme to identify problems at our brewery

How can we identify the problems?

Interview key personnel

Inspect the site

Collect and evaluate resource consumption data

Observe environmental problems

Solve the problems!

First the easy ones ...

... then the rest – one by one

Monitor and control – evaluate the progress

Decide what to measure, and why – keep records, and observe trends

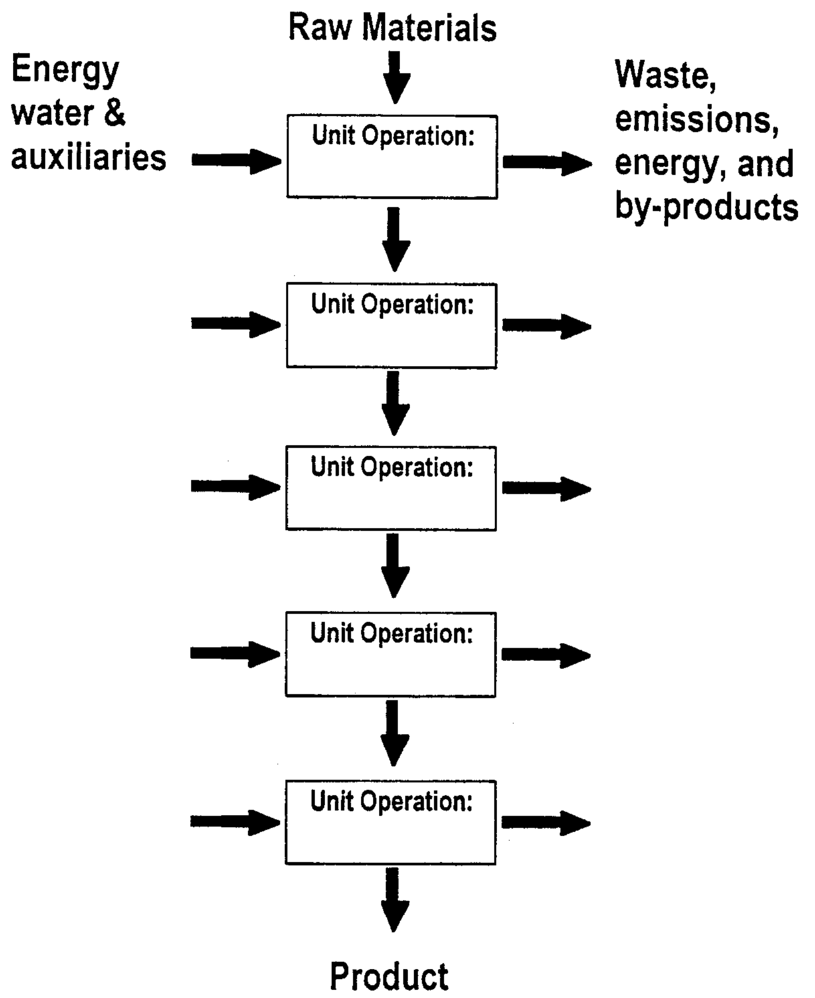
1 : Questions to be answered during a walk-through

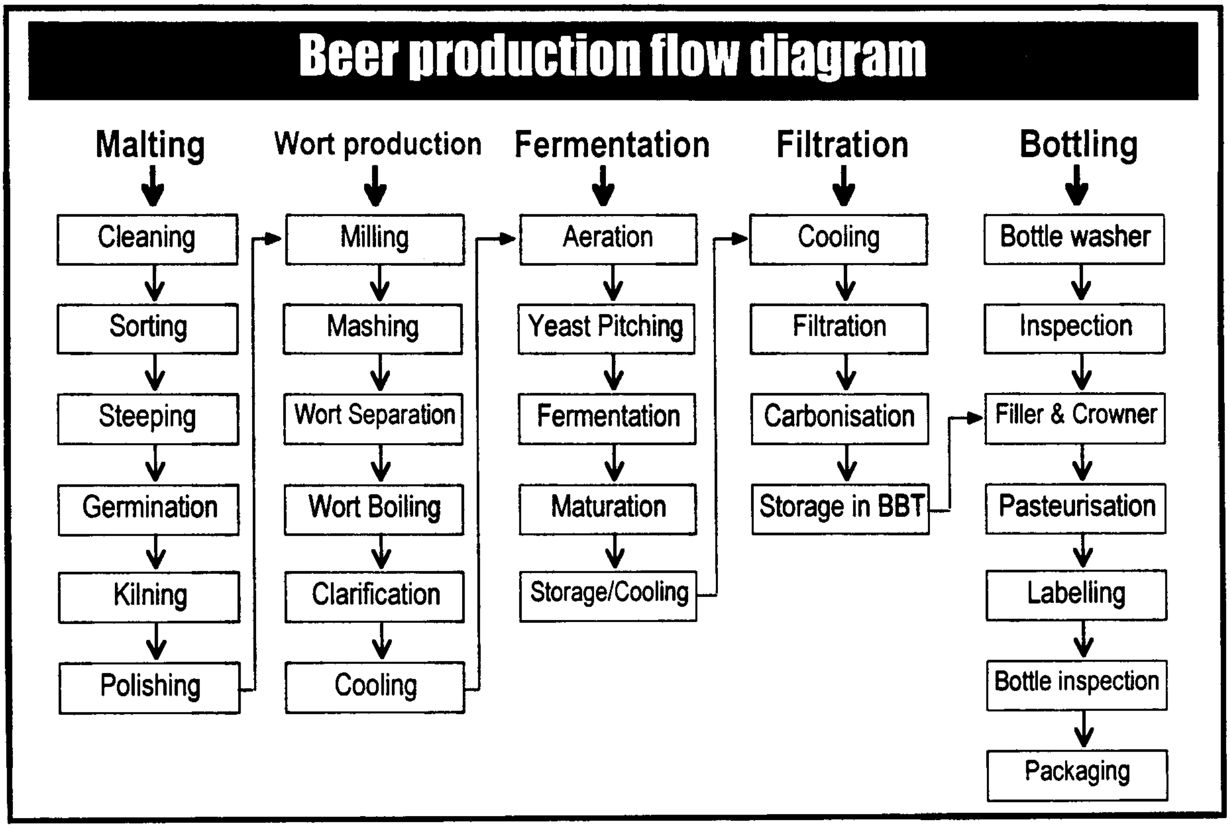
- Does the company show signs of poor housekeeping (cluttered walkways, unswept floors, uncovered material drums, etc.)?
- Are there noticeable spills or leaking containers, or is water dripping or running?
- Is there any discoloration or corrosion on walls, ceilings, work surfaces, or pipes that indicates system leaks or poorly maintained equipment?
- Do smoke, dirt or fumes indicate material losses?
- Are there strange odours, or irritation to the eye, nose or throat on entering the work place? These symptoms might indicate system leaks.
- Are all containers labelled as to their contents and hazards?

2 : Questions to be answered during a walk-through

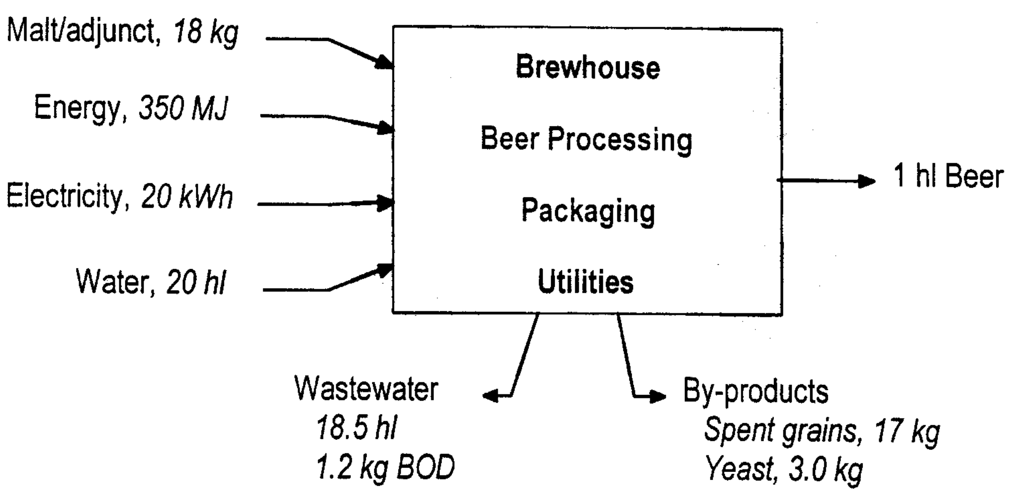
- Is there out-dated stock or materials in storage?
- Are there open containers, stacked drums, shelvings too small to handle inventory, or other indicators of poor storage procedures?
- Are waste and emissions generated from processes in the factory (dripping water or steam, evaporation, drag-out, etc.)?
- Is there a history of spills, leaks, accidents or fires in the company? Which processes were involved?
- Do employees have comments about the sources of waste and emissions in the company?
- Is emergency equipment (fire extinguishers, etc.) available and visible to ensure rapid response to a fire, spill or other incident?

Worksheet: process flow chart

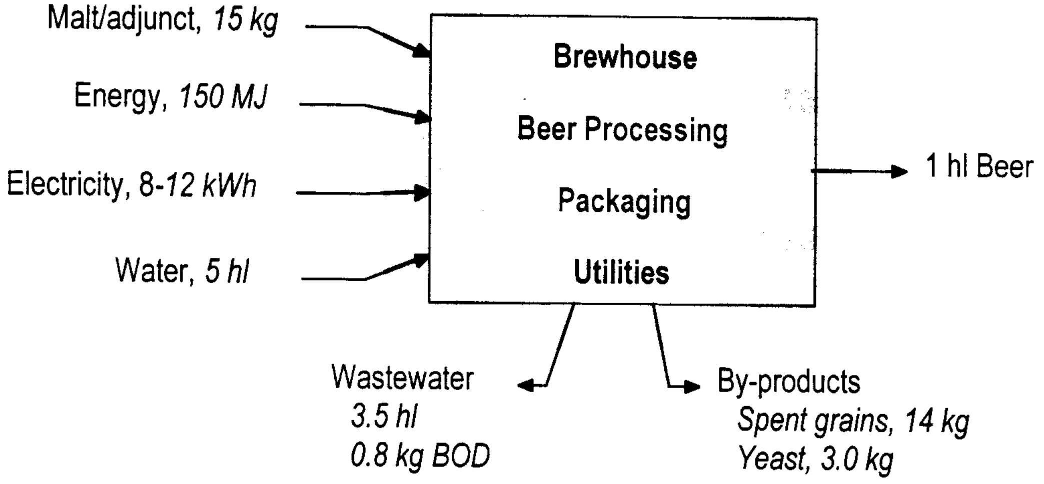



Beer production flow diagram
Malting
Cleaning
Sorting
Steeping
Germination
Kilning
Polishing
Wort production
Milling
Mashing
Wort Separation
Wort Boiling
Clarification
Cooling
Fermentation
Aeration
Yeast Pitching
Fermentation
Maturation
Storage/Cooling
Filtration
Cooling
Filtration
Carbonisation
Storage in BBT
Bottling
Bottle washer
Inspection
Filler & Crowner
Pasteurisation
Labelling
Bottle inspection
Packaging

Resource consumption in a high-consumption brewery



Resource consumption in a low-consumption brewery



Typical resource consumption data

in European breweries

Country	Water *(hl/hl)*	Heat *(MJ/hl)*	Electricity *(kWh/hl)*
Spain	5.3 - 11.9	114 - 262	9.2 - 19.7
Germany	6.6 - 8.6	153 - 244	11.0 - 16.0
United Kingdom	5.9 - 11.1	155	12.5
Norway	7.4 - 10.6	209 - 232	19.2
Denmark	4.1 - 8.7	120 - 228	6.6 - 16.9

Note 1 litre of oil equals 39.6 MJ

Typical resource consumption data

in Danish breweries

Materials	Amount per hl beer *(Average)*
Malt and cereals	**15 kg**
Kieselguhr (filter powder)	**80 - 570** *(255)* **g**
PVPP (Polyvinyl-poly-pyrrolidine)	**15 g**
Carbon dioxide	**0.83 - 3.06** *(1.83)* **kg**
Caustics (30% concentration)	**0.39 - 1.07** *(0.7)* **kg**

***Note** 1 litre of oil equals 39.6 MJ*

Typical problem sources in a brewery

Solid waste:	Kieselguhr
	Filter sheets
	Yeast
	Waste glass
Soil pollution:	Spilled oil
	Dumped waste oil
Air emissions:	Combustion gases from boilers
	Odour from wort boiling
Noise:	Bottling hall
	Engines and compressors

Wastewater problems

The characteristics for brewery wastewater are:

- very high organic loading
  mainly caused by wasted beer and discharged yeast
- high fluctuation in amount
  caused by batch cleaning
- high pH
  caused by discharge of caustic solutions
- high temperature
  caused by discharge of sterilization water

Wastewater characteristics

For a medium resource consumption brewery

Water to beer ratio	*4 - 10 hl water / hl beer*
Wastewater to beer ratio	*1.2 - 2 hl / hl lower than water to beer ratio*
BOD (no discharge of yeast)	*0.6 - 1.8 kg BOD / hl beer*
Suspended solids	*0.2 - 0.4 kg SS / hl beer*
COD / BOD ratio	*1.5 - 1.7*
Nitrogen	*30 - 100 g/m³ wastewater*
Phosphor	*30 - 100 g/m³ wastewater*
Heavy metal concentration	*very low*

Occupational Health and Safety problems

Noise in the bottling hall

Monotonous and repetitive work in bottle inspection

Exploding bottles

Handling of caustic

Leaking ammonia pipes

Cold working areas

Dust from malt silos

Alcoholism

Legal requirements

Some effluent standards

Wastewater discharge limits in various countries

Country	BOD *mg/l*	COD *mg/l*	SS *mg/l*	Total N *mg/l*	Total-P *mg/l*	pH	Temp ˚C
EU	25	125	35	10	1		
Denmark	15			8	1.5		<35
Germany	25	110		10	2		
Poland	30	150	50			6.5-9.0	<35
Malawi	20		30			6.5-8.0	
Tanzania	20			11	2	6.5-8.5	
India	30		100			5.5-9.0	
Thailand	20		30			5.0-9.0	
Malaysia	20	50	50			5.5-9.0	<40
Argentina	50					5.5-10.0	<40

Occupational Health and Safety problems

Air emissions

Danish air emission standard for boiler plants with capacity of > 50 MW

Particulates: < 2 g/kg fuel oil

Particulates: < 100 mg/Nm^3

Sulphur dioxide (SO_2): < 500 mg/Nm^3

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Part 5
Work Exercises

5 Work Exercises

5.1 Introduction

All the exercises can be carried out by individuals or in small groups, apart from the final exercise *Company Visit: Site Inspection Tour and Reporting*, which must be carried out at a brewery.

Working through the exercises will familiarize participants with the key parts of the cleaner production methodology. Thus, they should learn enough to initiate or even carry out a cleaner production programme in a brewery.

The workshop participants should be divided into groups of two to a maximum of four persons. Trainers will find information and hints in the case study in Part 3.2 *Case study: a brewery in East Africa*, to help them answer the questions.

Each of the groups should see themselves as a Cleaner Production project team that has to collect information, identify problems and their causes, suggest ideas for improvement and, if possible, calculate the potential savings.

Most of the exercises contain two types of question: one involving discussion, and the other involving calculation. In this workbook, space to write answers is provided only for the calculations. These answers can then be checked against the answers given in Part 6.

To enhance the exercises, the trainer is encouraged to locate the relevant local legislation and the cost of resources and materials used in breweries, so questions on these specific issues can be added.

The exercise on Occupational Health and Safety is meant for participants who work in breweries, or people who have a thorough knowledge of breweries and their working environment.

5.2 Preliminary work

5.2.1 Preparative work

Here are some tasks that participants can be asked to work on before the workshop:

Read through the workshop material and UNEP IE Technical Report No. 33 (1996) on Environmental Management in the Brewing Industry. Can the ideas on Cleaner Production from this material be used in your brewery? Can you apply the figures and the estimated savings in the technical guide?

List the main inputs and outputs:

- for a whole brewery
- for each of the departments: wort production, fermentation and maturation, filtration, and bottling
- for each production process (e.g. mashing, lautering, wort boiling etc.)

Write down all the environmental problems in breweries that you can think of.

Write down all the occupational health and safety problems in a brewery that you can think of.

What environmental regulations and standards apply to breweries in your country? What packaging/litter/waste disposal regulations affect the sale of beverages?

What are the local costs of the various forms of energy used in breweries in your country (e.g. electricity, oil, coal, gas)? Give your answer in a form that allows meaningful comparisons with energy alternative sources, i.e. taking account of the thermal efficiencies and end-use applications as the case may be.

At the beginning of the workshop, you should hold an interactive session to discuss answers and take feedback. *It is bad practice not to follow up on preliminary tasks.*

5.2.2 Interactive lessons

1: Inputs and outputs in breweries

Note: The aim of this lesson is to encourage the participants to list the typical inputs and outputs in a brewery. They can then consider which ones cause the environmental problems.

Ask what the typical inputs and outputs during production and cleaning are. The answers should be written down, preferably on flipcharts.

What are the inputs and outputs associated with a brewery?

Start with inputs and outputs at company level.

After listing the most important inputs and outputs, try to quantify the consumption of water and oil.

This can lead on to a discussion of why some breweries are using much more water and energy than others.

State the production process

Suggest production of a flow diagram.

What are the inputs and outputs for each department?

Break down inputs and outputs to department level; focus on the inputs and outputs that are specific for each department.

Do not forget the inputs and outputs caused by cleaning and normal maintenance. Do the outputs cause any environmental problems?

What are the inputs and outputs from selected processes?

If time is available, select some processes (such as pasteurising and beer filtration), and discuss the inputs and outputs for these processes.

What are the most polluting outputs from a brewery?

What are the most environmentally problematic inputs in a brewery?

You can either look at it from:

- an environmental resource perspective
- a pollution perspective.

An example of the first would be in the case of water being a limited source in the area, and of the latter where a material causes severe environmental problems when discharged.

Which legislation and discharge standards affect breweries in your country?

You could, for instance, focus on wastewater discharge or on occupational health and safety legislation.

2: Environmental and occupational problems

Note: The aim of this lesson is to identify environmental and occupational problems and solutions during a brainstorming session.

This lesson is very important, as it encourages the participants:

- to become actively involved
- to think in a 'problem identifying' manner
- to identify all possible problems that could occur.

Everybody should be encouraged to suggest problems. It is important that participants are told that it is a 'brainstorming session', where all problems – small or large, serious or not serious – should be mentioned and listed.

During the exercise, the problems should be written down on flipcharts. These can be displayed afterwards, so that participants can see the problems throughout the workshop.

Try to ensure that at least twenty problems get listed.

In a mixed group, some participants may wish their answers to remain anonymous. If this is the case, you can ask each person to write their answers on a piece of paper, and then you should pin all the papers on a board, or write them out yourself.

The problems can be categorized by production area or pollution type:

Figure 5.1 Categorizing problems by production area or pollution type

Production area	*Resource / pollution problem*
Brewhouse	*Water consumption*
Fermentation and maturation	*Energy consumption*
Filtration	*Solid waste*
Bottling	*Wastewater* *Air emissions* *Hazardous waste*
Engineering	*Soil pollution*
Car workshop	*Occupational health and safety*

If participants are a bit reserved, you can ask them directly if there are any environmental problems or occupational health problems in a specific department.

You could ask questions such as, "What does the wastewater contain?", or "Have you seen leakages or signs of poor handling of water in a brewery?".

To enable proper consideration of the problems, some detail should be given. For example, it would not be enough to say, "The water consumption is too high".

Once the listed problems have been discussed, turn the group's attentions to the causes of the problems. Ask questions such as:

- what is the cause of the problem?
- is there a underlying reason for the problem?
- how can the cause of problem be tackled and the problem solved?

The participants should then talk about solutions to the problems. Make sure that they consider the impact of their solutions. Sometimes the solution can be more trouble than the problem.

The solutions can be grouped into:

short term; intermediate term; long term.

The solutions can also be categorized as follows:

- Good housekeeping and maintenance
- Process optimization
- Material substitution
- Internal recycling
- New process equipment.

5.2.3 Site inspection of a brewhouse

> *Note: The aim of this exercise is to indicate the type of information a project team can obtain during the first site inspection tour.*

Instead of carrying out an actual site inspection, the information needed for this exercise can be found in the case study in Part 3. The description, in Sections 3.2.4 to 3.2.6, relates to a thorough site inspection in a brewhouse.

Please read the description and then answer the questions. The information may be inadequate to evaluate the problems, but that is often the case after a site inspection tour!

1 Make a process diagram for the brewhouse, and show the inputs and outputs for each of the production processes.

2 List the inputs and outputs from weekly cleaning.

3 What energy problems can you identify in the brewhouse? How can the energy consumption in the brewhouse be reduced?

4 Have you found any problems with water consumption? What are they?

5 Does the brewing and cleaning processes causes any wastewater problems?

6 Does the description indicate poor occupational health and safety?

7 Does the steam from wort boiling cause any environmental problems? If so, what are they?

8 Because of a poor hot water balance, leakages of steam and discharge of hot water result in a higher consumption than necessary.
What environmental problems are caused by steam generation?

The answer to this question can be found on page V:30

9 Normally, production data will not be available after a short site inspection. However, *Tables 3.1* and *3.2* in Part 3 contain data from a 1993 inspection.

What is the annual wort production, and how much malt is used per hl wort? *(1 hl = 100 l)*

The answer to this question can be found on page V:30

10 For a brewery that uses returnable bottles, a rule of thumb says that 60% of the heat energy is used in the brewhouse, fermentation and filtration.

(a) If this is the case, how much oil is used per hl of wort?

(b) How much in US$ will the brewery save if it can reduce its oil consumption to 2.8 l/hl wort?

The answer to this question can be found on page V:30

5.3 Identify the cause of environmental problems

> *Note: The aim of this exercise is to identify the underlying causes of problems. The exercise should be done in groups of two to four people.*

It is important to try to find the underlying reasons for any problem, thereby solving the real – rather than the apparent – problem. For instance, the first and obvious solution to a high water consumption problem might be to install high pressure cleaning nozzles. Looking further into the problem, however, may reveal that the cleaning can be done without water.

This exercise is based on problems identified in a filtration room, where beer is filtered through a coarse filter and a polishing filter.

The production process

The production process is described in the case study in Section 2 of Part 3. You will find a brief summary below.

The green beer is transferred from the unitank farm to the beer processing room. Prior to filtration, a kieselguhr slurry is injected in the beer to facilitate removal of the remaining yeast and suspended solids. The beer is then filtered, first through a coarse filter and then through a polishing filter. The beer sometimes needs to be recirculated until any haze disappears. After filtration, the green beer is cooled to 0°C, carbon dioxide is added, and the beer is stored in the bright beer tanks until needed in the bottling hall.

The speed of filtration varies with the filterability of the beer, but is around 100-240hl per hour. The filter is backwashed when the filter resistance is too high. When the filter is opened, the push water is discharged; the filter cake is removed with water, and is then discharged into the sewer. Before filtration can proceed, the filter is assembled and pre-coated. Push beer is discharged into the sewer.

The cleaning of the filtration room is done on Saturdays. Hot caustic from the brewhouse is circulated through the beer mains in the beer processing room. The bright beer tanks are cleaned every time they have been emptied, and the floor is cleaned every day. The BBTs are cleaned with water and caustic, and the tanks are checked daily for any infection.

It is important that you address each problem carefully and try to find effective and efficient solutions to the problems. The best solutions are often found by identifying the cause of a problem, and then solving the problem at source.

Identified problems

- ***a*** The kieselguhr slurry, mixed with yeast, is washed out to the sewer during backwashing.
- ***b*** The water consumption during backwashing and cleaning of bright beer tanks is very high.
- ***c*** The filter runs are short. This results in frequent back washing, with loss of push beer and water.
- ***d*** The consumption of kieselguhr and filter sheet is very high compared to other breweries.
- ***e*** The filtration quality and carbon dioxide content of the beer are uneven.
- ***f*** The room is cooled down to a temperature of around 11-14°C with air coolers. This temperature level is maintained to avoid too large a temperature take-up during filtration. It has not been established whether the temperature take-up is mainly during filtration or is caused by the beer pumps.
- ***g*** There is a steam mixer without condensate return in the room. It is leaking and is sometimes used by the workers to warm themselves.
- ***h*** The cold and wet working area gives poor occupational health and safety conditions.

11 From the data in *Tables 3.1* and *3.2* in the case study in Part 3, calculate the annual consumption of filter sheet and filter powder:

The answer to this question is on page V:30

12 The amount of beer filtered can be calculated from the sum of bottled beer and the beer losses in the bottling hall. What is the consumption of filter sheets and filter powder per hl of filtered beer?

The answer to this question is on page V:30

13 What are the causes of problems ***a-h***, listed on the previous page? Discuss every problem and write down the causes and action steps, as in the following example:

Example: ***Some causes for problem C (short filter runs)***

Cause 1: Either the dose of filter powder is too low or there is too high a content of solids, and yeast remains in the beer from the unitanks.

As the dose of filter powder is very high, the cause is probably a high content of solids and yeast remains.

Cause 2: A high solids content in the beer can be caused by poor settlement of solids, due to:

- too short a settling time, or an uncontrolled settling temperature
- the wrong dose of settling agent (chemical)
- a high content of poorly settling matter.

As the beer is cooled down to 0°C four days prior to filtration, the solids should have time to settle properly.

Cause 3: A high content of poorly settling matter in the beer can originate from the quality of the wort, and thus from the quality of malt.

Actions needed

To solve this problem, the following actions should be taken:

- check that the temperature is kept at 0°C (yes)
- is the dosing of settling agent optimal? Carry out settling test.
- the malt quality is poor, but this is a very difficult problem to solve, as import of good malt costs foreign currency.

5.4 Evaluation of Cleaner Production options

Note: The aim of this exercise is to use different methodologies to evaluate the options for solving the problem. After this exercise, participants should be able to understand and apply the different approaches. Provide copies of the evaluation sheets given in Sections 5.4.1 to 5.4.6.

This exercise contains:

- the problems and solutions identified at an old bottle washer
- a set of technical, economic and environmental evaluation criteria
- a simple evaluation sheet based on technical and economic evaluation criteria
- a series of five evaluation sheets to make a feasibility study of the options.

Before the project team selects the best cleaner production options, it should discuss and decide the evaluation criteria that are most important for the brewery.

14 From the different evaluation criteria stated on next page, you should select those which you (as a project team) find most important. Please rank in order the criteria that you consider most important.

15 Use the simple evaluation sheet on page *V:13* to evaluate the eight possible options. Which options would you recommend to the plant manager?

16 Use the five evaluation sheets (Feasibility Study sheets) on pages *V:14* to *18* to evaluate the possible solutions. Rank and list the options after the evaluation.

17 Compare the results from the two different evaluation methodologies:

(i) What are the advantages and disadvantages of each of the methodologies?

(ii) Do the different methodologies give different recommendations on which actions to take first?

(iii) Which method is most effective?

Problem

The consumption of caustic soda in the bottle washer is 8 440kg per month, which is very high compared to other breweries. For example, it is more than twice the normal consumption in Denmark.

The high consumption, and hence the high discharge of lye, has several causes. These are:

- overfilling of the caustic tanks during re-fill (both physical overflow and too high concentrations after re-fill)
- the specified concentration of caustics is high at 3-4%, when the normal concentration is 2%
- the short lifetime of the lye (discharged every third week) because:
  - the label extractors are not working
  - the lye is diluted because of perforation in the steam pipes
  - bottles are very dirty, due to dusty roads and long storage times.

Description of the possible options

Option 1

Change working procedures in order to determine the exact amount of caustic required for the job. Do the calculations before re-filling, and weigh off more accurately (perhaps using volume to estimate the weight). Increase the lye concentration in the mixing vessel in order to reduce the volume of lye, and thereby minimizing the risk of overflow.

Option 2

Install a concentrated lye solution chamber on top of the bottle washer to add very small and precise amounts of concentrated caustic. This will make it possible to keep the concentration close to the specifications.

Option 3

Replace the steam condensers to avoid dilution of the lye. This is a major repair, because the condenser pipes are hard to get at.

Option 4

Repair the label extractors, because continuous removal of the labels will ensure a longer lifetime of the caustic. Furthermore, the labels can be disposed on a landfill instead of being discharged into the sewer, where they add to the organic load.

Option 5

Investigate the possibility of changing the specifications and operating with a lower lye concentration.

Option 6

Consider continuous filtration of the lye solution, to increase its lifetime and improve the quality.

Option 7

Most breweries have a recovery tank for caustics. During the weekends, the caustic is pumped into an insulated settling tank, where most of the particles settle. When returning the caustic to the bottle washer, it is free of organic matter and will last longer. Normally, the lifetime is increased from three weeks to three months.

Option 8

Repair the sight glasses, so it is possible to see when the caustic chambers are full. This will enable the operator to stop the pump before overflow.

All these are possible solutions. Now participants should consider what can be implemented right away and what will have to wait.

Evaluation criteria

Availability	Is the Cleaner Production option available?
	Can you find someone to supply you with the necessary equipment or input material?
	Do you know an advisor who can help you to develop an alternative?
	Has the Cleaner Production option already been applied elsewhere?
	If so, what are the results and experiences?
Suitability	Does the option fit in with the way the company is run?
	Is the option in line with the company's product?
	What are the consequences of the options for internal logistics, throughput time and production planning?
	Does the option require adjustments in other parts of the company?
	If so, what adjustments?
	Does the change require additional training of staff and employees?
Environmental effects	What is the anticipated environmental effect of the option?
	How big is the estimated reduction in waste streams or emissions?
	Will the option affect public or worker health?
	If so, what is the magnitude of these effects in terms of toxicity and quantity (positive/negative)?
Economic feasibility	What are the anticipated costs and benefits from implementing the option?
	Can you estimate the required investment?
	Can you make an estimate of the benefits, such as reduction of environmental costs, reduction in wastage, and/or improving the quality of the product?

Some environmental performance indicators for breweries

Solid waste
Hazardous waste
Wastewater
Air emissions
Noise
Odour

Water consumption
Energy consumption
Raw material consumption

Environment
Occupational health and safety

Payback period
Cost
Production quality
Production quantity

Legal regulations

Stakeholders' demands

5.4.1 A simple evaluation sheet

Cleaner Production option	Time span for implementation			Expected investment cost			Expected running cost			Priority
	short	medium	long	low	medium	high	lower	same	higher	

5.4.2 Checklist for the feasibility study

This checklist can be used to help organize the Feasibility Study Phase.

		yes	no	not relevant
1	Have you conducted a technical evaluation for the prioritized options?			
2	Have you conducted an economic evaluation for the prioritized options?			
3	Have you conducted an environmental evaluation for the prioritized options?			
4	Have you determined the training that employees will need for successful implementation of the selected options?			
5	Do you understand the barriers to the implementation of the cleaner production options which can be encountered on the workfloor?			
6	Have you taken measures to facilitate the implementation of these options, such as workshops, meetings, briefings, and so on?			
7	Have you documented the feasible options which are selected for implementation?			
8	Have you documented the non-feasible options?			
9	Have you adjusted the planning and time schedule for the Cleaner Production Assessment or audit?			
10	Have you informed management and employees about the progress of the Cleaner Production Assessment?			
11	Have you prepared before-and-after sheets for the implementation phase?			
12	Based on the expected 'before-and-after' situation, have you calculated the expected payback period?			
13				
14				

5.4.3 Technical evaluation

Cleaner Production option:			
	yes	no	not sure
1 Have you determined whether other companies already have experience with this?			
2 Will this option maintain product quality?			
3 Will this option adversely affect production?			
4 Will this option require additional staff?			
5 Will workers be able to run the process with the implemented option?			
6 Is extra training of workers required?			
7 Are you certain that this option will create less waste?			
8 Are you certain that this option will not simply move waste problems from one medium into another (e.g. from solid waste to air emissions)?			
9 Is your plant layout and design capable of incorporating this option?			
10 Will the vendor guarantee this option?			
11 Have you determined that this option will improve or maintain worker safety and health?			
12 Does this option reduce wastes at their source?			
13 Are materials and parts readily available?			
14 Can this option be easily serviced?			
15 Does this option promote recycling?			
16			
17			

5.4.4 Economic evaluation

Cleaner Production option:			
	yes	no	not sure
1 Does this option reduce the cost of raw materials?			
2 Does this option reduce the cost of utilities?			
3 Does this option reduce material and waste storage costs?			
4 Does this option reduce compliance costs?			
5 Will this option reduce the costs associated with worker injury or illness?			
6 Will this option reduce your insurance premiums?			
7 Will this option reduce your waste disposal costs?			
8 Does this option have an acceptable payback period?			
9 Is this option within your price range (consider both capital and ongoing operations)?			
10			
11			

5.4.5 Environmental evaluation

Cleaner Production option:			
	yes	no	not sure
1 Does this option reduce the toxicity and volume of solid waste and sludge?			
2 Does this option reduce the toxicity and volume of wastewater?			
3 Does this option reduce the toxicity and volume of gaseous emissions?			
4 Does this option improve the health and safety conditions on the workfloor?			
5 Does this option reduce the use of raw materials (per product)?			
6 Does this option reduce the use of auxiliaries (per product)?			
7 Does this option reduce the energy consumption (per product)?			
8 Does this option create new environmental impacts?			
9 Does the option increase the possibility of recycling the waste streams?			
10 Does this option increase the possibility of recycling the product?			
11			
12			

5.4.6 Select feasible options

Cleaner Production option	Expected technical feasibility			Expected economic feasibility			Expected environmental feasibility			Feasible option? *yes / no*
	low	medium	high	low	medium	high	low	medium	high	

5.5 Occupational health and safety

> ***Note:*** *The aim of this exercise is to:*
> - *look at some occupational health and safety problems in breweries*
> - *emphasize the advantages of taking account of occupational health and safety in the Cleaner Production programme.*

When looking at ***occupational health and safety (OHS)*** problems and how to solve them, it is important to note that it is much better to remove the problems rather than provide employees with personal safety equipment.

When answering the questions below, it would be useful to divide the problems into:

- ***physical problems:*** noise, heavy workload, cold and warm areas
- ***chemical problems:*** handling of chemicals, e.g. caustic and ammonia
- ***psychological problems:*** stress, high working speed, monotonous and repetitive work.

---

1 What are the OHS problems in a bottling hall in connection with the:

- bottle washer?
- bottle inspection sites?
- pasteurizer?
- conveyors?
- filler and crowner?
- palletizer?

2 What can be done to minimize the risk of accidents and impaired hearing in the bottling hall? (There are solutions other than safety goggles and earplugs!)

3 Drinking is bad for health in general. In addition, it increases the risk of accidents. Most breweries have had, and some still have, problems with a few people drinking during working hours, especially in the cold rooms and the bottling hall. What can be done to eliminate drinking?

4 What are the advantages of a good occupational health and safety environment?

Discuss this issue and come up with at least five good arguments to convience the plant manager to take OHS seriously.

5 How can the occupational health and safety environment be continuously improved in all departments in a brewery?

5.6 Brewery wastewater

Note: This exercise focuses on the organic pollution that breweries cause.

A **brewery with a yearly production** of about 220 000hl of bottled beer discharges its wastewater directly to a river nearby.

According to the technical report *Environmental Impacts of the Brewing Industry*, a typical high consumption brewery has a discharge of organic matter that results in 1.8kg of BOD5 per hl of beer. (BOD5 is Biological Oxygen Demand measured over a five day period.)

18 The amount of wastewater discharged from a brewery was measured with a rectangular weir. Figure 3.5 in Part 3 shows the fluctuation in the wastewater. What is the approximate average flow during the four-day measuring period?

The answer to this question can be found on page V:31

19 When measured over a longer period, it was found that the average wastewater discharge was $76m^3/h$ from Monday to Friday and $46m^3/h$ during the weekends. What is the yearly wastewater discharge from the brewery?

The answer to this question can be found on page V:31

20 The concentration of COD was measured to an average of 2.8g COD/l of wastewater.

(i) What is the average BOD concentration?

(ii) What is the BOD to beer ratio (g BOD/hl beer bottled)?

The answer to this question can be found on page V:31

21 What might be the reason for such a high discharge of organic matter?

The answer to this question can be found on page V:31

22 According to the legislation in your country, how many times does the brewery exceed the discharge limit?

23 How can the wastewater problem be solved?

5.7 Water consumption

> *Note: The aim of this exercise is to focus on high water consumption problems, and how they can be solved.*

Good **drinking water** is a scarce resource in many regions of the world. However, most breweries use very high quantities of water. The reason for this is that water is very cheap compared to other materials or electricity, and that management and employees are not really aware of their water consumption. Breweries that uses the best available technology can manage with only 3.5 litres of water per litre of beer.

At a brewery that was starting up with a Cleaner Production programme, the water consumption was not measured. The flow meters were out of order, and it was not possible to obtain spare parts within the fiscal year. Thus, the brewery paid a fixed price for water every month. To get an idea of the level of water consumption, the amounts of wastewater were measured with a rectangular notch.

24 What is the wastewater to beer ratio? (If you have worked through the questions in *Section 5.2*, then this should be a very easy question):

The answer to this question is on page V:31

25 State a qualitative water balance for the whole brewery:

26 ***(i)*** What are the quantitative outputs of water per hl of bottled beer?

(ii) Based on this, what is the water consumption per hl of bottled beer?

The answer to this question is on page V:31

27 ***(i)*** Which processes involve high water consumption in a brewery?

(ii) Can normal production and cleaning practice alone be responsible for the high water consumption?

The answer to this question is on page V:31

28 ***(i)*** What are your first recommendations on what the brewery should do to reduce the water consumption?

(ii) What should the brewery do to control future water consumption?

The answer to this question is on page V:31

29 How much will the brewery save on an annual basis if it reduces its water consumption to 12 litres per litre of beer?

The answer to this question is on page V:31

30 How would you initiate a water saving campaign at a brewery?

What information and posters would you distribute amongst the departments?

5.8 Environmental monitoring

Note: The aim of this exercise is to introduce monitoring as an important part of any environmental management system. Continuous environmental management and commitment demands data collection on key environmental performance indicators.

Continuous improvement in a brewery's environmental performance requires the measurement and control of resource consumption and waste generation. However, it can be very difficult and time consuming to collect data on all inputs and outputs. Thus, it is important to focus the data collection on a few important parameters. ***Figure 5.1*** gives some examples of key figures, but it will often be too complicated to collect and evaluate all these data.

Figure 5.1 Key measurements in the control of environmental performance

Consumption of	oil, electricity, water, spirits, ammonia, freon, caustic soda, sterilant, filter sheets, filter powder, bottles / cans, malt, adjuncts, hops
Generation of	bottled beer, waste oil, hazardous waste, air emissions, solid waste, wastewater, BOD concentration, pH in wastewater, yeast discharge, glass waste
Occupational health and safety	accidents, safety equipment

Many solutions demand employee involvement – for example, reducing water consumption through better housekeeping requires employees to be informed about current water consumption and target water consumption.

31 Select the parameters which you will monitor and control in the future.

32 Based on your answer to Question 31, identify the key figures (i.e. environmental performance parameters) that you would issue to the employees in every department on a monthly basis.

33 Organise an environmental monitoring team:

- Who should be responsible for the data collection and compiling?
- Where can the data be found?
- What should the information chart in every department look like (which data, which graphs ...)?

To ensure that environmental issues become a part of daily management, it is necessary to discuss it during production meetings and board meetings.

34 How would you build up a management system that includes environmental and occupational issues? (This is a short question, but the answer can be very long!)

The management system could/should include:

- who is responsible for what
- regular data collection and compiling
- regular discussion of environmental problems
- progress evaluation meetings
- appropriate training

5.9 Company visit: site inspection tour and reporting

Note: The aim of this exercise is to use some input/output sheets and to identify environmental and occupational problems at the brewery. The following pages include worksheets and 'Questions to be answered during a Walk-Through'.

Site inspection

The course participants should be divided into project teams, and spend half a day at a brewery. Each project team should be responsible for the survey of one department.

The site inspection tour should include employee interviews to elicit enough data to complete the site inspection sheet and identify problems.

Reporting

After the site inspection, the project teams should make a description of the departments.

This description should include information on:

- the department/area
- the machinery in use (and not in use!)
- the production and cleaning processes
- inputs to and outputs from the department/area.

After the short inspection, it should be possible to list some environmental and occupational health problems, and perhaps some solutions. These problems and solutions should be outlined in some detail.

The project teams should have half a day to complete their site visit report. These reports should be copied and distributed to the other workshop participants.

Discussion and evaluation

On the following day, the reports should be discussed and evaluated.

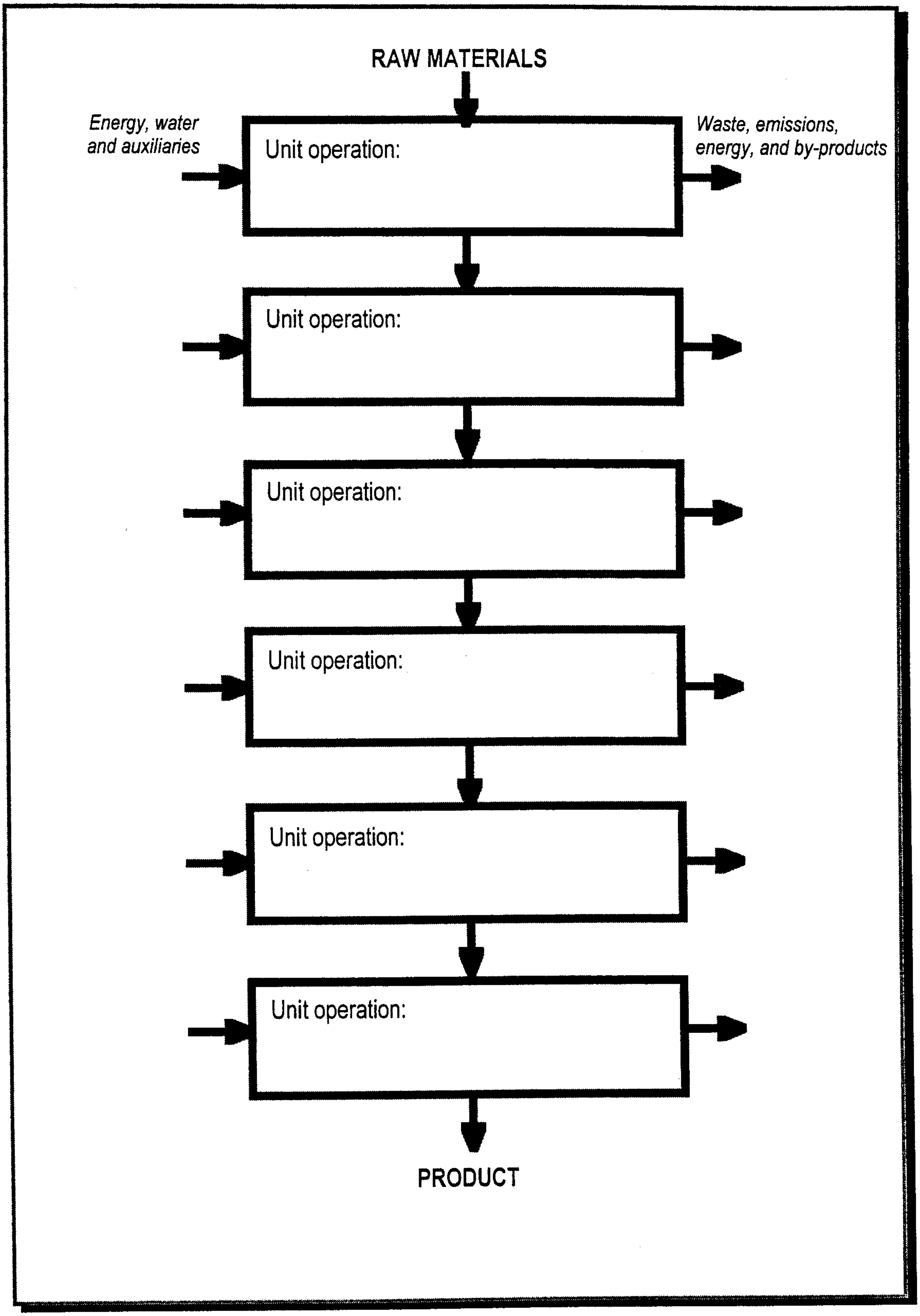
Questions to ask include:

- do the reports contain the necessary information?
- are they well structured?
- do they contain a list of further information that should be collected?

5.9.1 Questions to be answered during a walk-through

- Does the company show signs of ***poor housekeeping*** (cluttered walkways, unswept floors, uncovered containers, etc.)?
- Is there ***evidence of spills***, leaking containers, dripping or running water?
- Is there any discoloration or corrosion on walls, work surfaces, ceilings and pipes? This may indicate ***system leaks*** or ***poorly maintained equipment***.
- Is there smoke, dirt or fumes to indicate ***material losses***?
- Are there any strange odours, or do you experience eye, nose or throat irritation when first entering the workplace? These symptoms might indicate ***system leaks***.
- Is there any ***out-dated stock*** or materials in storage that are no longer in use?
- Are there open containers or stacked drums? Is the shelving too small to properly handle inventory? Are there or other indicators of ***poor storage procedures***?
- Are all containers ***labelled*** with information about their contents and hazards?
- Do you notice ***waste and emissions*** being generated from processes (dripping water or steam, evaporation, drag-out, etc.)?
- Is there a ***history*** of spills, leaks, accidents or fires in the company? Which processes were involved?
- Do ***employees*** have any comments about the sources of waste and emissions in the company?
- Is ***emergency equipment*** (fire extinguishers, etc.) available and visible to ensure rapid response to a fire, spill or other incident?

5.9.2 Worksheet: inputs and outputs



5.9.3 Worksheet: description of activity

Area:	**Activity:**	**Number:**	**Installed in year:**
The aim of the activity:			
Description of the activity:			
Condition of machinery:			
Operation cycle:			
Inputs		**Outputs**	
Main input:		Product:	
Materials:		By-product:	
Hazardous materials:		Emissions to air:	
Electricity:		Noise:	
Heat/steam:		Solid waste:	
Cooling:		Hazardous waste:	
Water:		Waste:	
Description of cleaning and maintenance:			
Cleaning inputs		**Cleaning outputs**	
Detergents:		Wastewater:	
Chemicals:		Waste:	
Water:			
Occupational health and safety issues			
Chemical impacts:			
Noise:			
Working load:			
Risk of accidents:			
Physical working conditions:			
Problems and ideas for solutions			
Environmental problems:		Solutions?	
Occupational health problems:		Solutions?	

5.10 Answers

Please note that answers to only some of the questions are provided here. This is because the exact answers to many of the questions depend on local circumstances. More guidance can be found in the UNEP Technical Report, Environmental Management in the Brewing Industry.

Answers are provided to the following exercises:

*5.2.3 **Site inspection of a brewhouse***

*5.3 **Identify the cause of environmental problems***

*5.6 **Brewery wastewater***

*5.7 **Water consumption***

5.10.1 Answers: Site inspection of a brewhouse

Question 8

As shown in Table 3.4 in Part 3, combustion of oil emits carbon dioxide and sulphur dioxide, which add to the greenhouse effect and to acid rain, respectively. Furthermore, oil is a limited resource.

Question 9

- **Annual wort production** .... ***268 500 hl***
- Annual malt consumption .... *3 745 000 kg*
- **Malt per hl wort** .... ***14 kg/hl***

Question 10

- Annual oil consumption .... *2 113 000 l*
- 60% of annual consumption .... *1 267 800 l*
- Oil per hl of wort (only brewing) .... *4.7 l/hl*
- Oil reduction per hl (4.7 – 2.8) .... *1.9 l/hl*
- **Annual oil reduction (1.9 x 268 500)** .... ***510.150 l***
- **Annual savings** .... ***176 300 US$***

5.10.2 Answers: Identify the cause of environmental problems

Question 11

- Annual consumption of filter sheets .... ***3 939 pieces***
- Annual consumption of filter powder .... ***96 755 kg***

Question 12

- Annual beer filtered .... *234 38 l*
- **Filter sheets per hl beer filtered** .... ***0.017 pieces/hl***
- **Filter powder per hl beer filtered** .... ***0.41 kg/hl***

5.10.3 Answers: Brewery wastewater

Question 18

Approximate average wastewater flow during the four-day measuring period .... ***78-80 m^3/h***

Question 19

Yearly discharge = *52 weeks x 24 h/d x (5d x 76m^3/h + 2d x 46m^3/h)* .... approximately ***590 000 m^3/year***

Question 20

(i) **BOD concentration** (2.8/1.8) .... ***1.55g BOD/l***

(ii) Bottled beer...*220 000 hl*

Annual BOD load (1.55gl x 590 000m^3).. *91 800kg BOD*

BOD to beer ratio ....***4.1kg BOD/hl beer***

Question 21

The reasons for such a high discharge of organic matter include ***high losses of beer*** and ***discharge of yeast.***

5.10.4 Answers: Water consumption

Question 24

- Actual bottled beer.. *227 000 hl/year*
- Wastewater per bottled beer..................... *590 00m^3 / 227 000 hl beer*
- **Wastewater to beer ratio**............................. ***approximately 26 hl/hl***

Question 26

(i)

Input	**Output**
Water source	Beer .... *(1 hl/hl)*
	Wort boiling .... *(0.1 hl/hl)*
	Evaporation from e.g. cooling tower .... *(?)*
	Surplus yeast *(3 l/hl)*
	Spent grains .... *(15 l/hl)*
	Kieselguhr .... *(1 l/hl)*
	Wastewater...................................... *(26 hl/hl)*

(ii) The water consumption is approximately ***2.73m^3 per hl beer bottled.***

Question 27

(i) Processes with high water consumption are: mashing; sparging; cleaning of bottles; soap lubrication of conveyors; vacuum pump for filler; flushing of filler; rinsing and cleaning of process equipment; cleaning of floor; cooling purposes.

(ii) Very high water consumption is often caused by ***leaking water pipes and valves***, and general ***poor housekeeping***. Normal production and cleaning alone cannot be responsible for a water consumption of 25 hl/hl.

Question 28

(i) The first recommendation should be to ***repair valves*** and to train employees in ***better housekeeping***.

(ii) Secondly, ***flow meters*** should be installed as soon as possible.

Question 29

- Savings: *27.3 l/l – 12 l/l*.. *15.3 l/l*
- Annual savings *(227 000 hl x 15.3 l/l)*...............................*347 300 m^3*
- **Annual savings *(US$0.2 / m^3)*** ....***70 000 US$***

UNEP

Appendices

Appendix I

Supporting Documents for this Package

During trials, the following documents were shown to be of great use in supporting the use of this package. They form an integral part of the package.

Environmental Management in the Brewing Industry [1996]
Technical Report No. 33. UNEP IE.

Audit and Reduction Manual for Industrial Emissions and Wastes [1991]
Technical Report No. 7. UNEP/UNIDO.

Cleaner Production Worldwide [1993] UNEP IE.

Government Strategies and Policies for Cleaner Production [1994] UNEP IE.

Climate Change and Energy Efficiency in Industry [1991] UNEP/IPIECA.

Training Course: ***Ecologically Sustainable Industrial Development*** [1994] UNIDO.
This trainer course embraces many of the issues addressed in this package. It might be very usefully employed in combination with this package.
Available from UNIDO, PO Box 300, A-1400 Vienna, Austria;
or UN Publications, CH-1211 Geneva 10, Switzerland.

Appendix II

List of Training Resource Packages available from UNEP IE

The following training resource packages have been developed by UNEP IE. They all use interactive training methodologies to explain the subject, and are aimed at educators who, although technically skilled, may not have specialized knowledge in this particular area. The packages are available from UNEP IE.

Some trainers' packages are still under development, and users are encouraged to assist UNEP to bring these to a final stage of publication.

Due to the cost of printing of the packages (between 100 and 400 pages), the completed documents are offered for sale to most users. However, a limited number of draft packages are free of charge to users prepared to contribute to their further development through review, field testing and adding material. Assistance with translation would also be welcome.

***Cleaner Production**: a Training Resource Package* [1996] First Edition. Contains background reading, transparencies, bibliography, and work exercises. 110 pages. Price $120 (English, Spanish). This package can be used with the workbooks below.

Trainer's Workbook on ***Cleaner Production in Leather Tanning*** [1996] First Edition. Contains background reading, case studies, work exercises and answers. 120 pages. Price $120.

Trainer's Workbook on ***Cleaner Production in the Brewing Industry*** [1996] First Edition. Contains background reading, case studies, work exercises and answers. 75 pages. Price $100.

Trainer's Workbook on ***Cleaner Production in Textile Wet Processing*** [August 1995] First Edition. Contains background reading, case studies, work exercises, answers, references. 140 pages. Price $120.

***Management of Industrial Accident Prevention and Preparedness**: a Training Resource Package* [1996] First Edition. Contains background reading, case studies and work exercises. 110 pages. Price $120. This package also helps to explain the APELL programme.

***Risk Management of Contaminated Industrial Land**: a Training Resource Package* [1996] First Edition. Contains background reading, case studies and work exercises. 110 pages. Price $120. English, Spanish.

***Hazardous Waste, Policies and Strategies**: a Training Manual* [December 1991] TR10. Contains background reading, case studies, work exercises, reference tables and bibliography. 250 pages. Price $120. English, French, Spanish.

***Landfill of Hazardous Industrial Wastes**: a Training Resource Package* [March 1994] TR17. Contains background reading, case studies, work exercises, reference tables and bibliography. 315 pages. Price $120.

***Environmental and Technological Issues related to Lead-Acid Battery Recycling**: Trainers Worbook* [1996] First Edition. Contains background reading, transparencies, bibliography and work exercises. 130 pages. Price $120.

***Environmental Management of Mining Sites**: a Training Manual* [1995] UNEP/DDSMS. Contains background reading, transparencies, case studies, work exercises and answers. 200 pages. Price $160.

***Environmental Management Systems**: Training Resource Kit* [1995] UNEP/ICC/FIDIC. Contains background reading, transparencies, case studies, work exercises, bibliography. 492 pages. Price $190.

Aerosol Conversion Technology Handbook [1994] Price FF225/US$45 for developed countries.

Training Manual on Chillers and Refrigerant Management [1994] Price FF425/US$85 for developed countries.

Training Manual on Good Practices in Refrigeration [1994] Price FF400/US$80 for developed countries.

***Environmental Impact Assessment:** a training resource manual* [1996] Preliminary version. Available from UNEP Environment and Economics Department, UNEP, Nairobi.

Enquiries **UNEP IE**
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39-43 quai André Citroën
75739 Paris Cedex 15
France
Tel 33 (1) 44 37 14 50
Fax 33 (1) 44 37 14 74
Email .... unepie@unep.fr
http://www.unepie.org/home.html

Appendix III

About UNEP Industry and Environment

Industry and Environment was established by UNEP in 1975 to bring industry and government together to promote environmentally sound industrial development.

UNEP IE is located in Paris and its goals are to:

1 encourage the incorporation of environmental criteria in industrial and development plans;

2 facilitate the implementation of procedures and principles for the protection of the environment;

3 promote the use of safe and clean technologies;

4 stimulate the exchange of information and experience throughout the world.

UNEP IE provides access to practical information and develops co-operative on-site action and information exchange backed by regular follow-up and assessment. To promote the transfer of information and the sharing of knowledge and experience, UNEP IE has developed three complementary tools:

- technical reviews and guidelines;
- *Industry and Environment:* a quarterly review;
- a technical query-response service.

In keeping with its emphasis on technical cooperation, UNEP IE facilitates technology transfer and the implementation of practices to safeguard the environment through promoting awareness and interaction, training and diagnostic studies.

Some relevant UNEP IE publications

Refer to Appendix II for trainers' packages. For complete list, refer to publications catalogue.

Industry and Environment [quarterly] deals with issues relevant to industrial development, such as auditing, waste management, industry-specific problems, and environmental news.

Government Strategies and Policies for Cleaner Production [1994] 32pp.

Cleaner Production Worldwide Vol. I and II [1995] 48pp.

Life Cycle Assessment: what it is and how to do it [1996] 92pp.

Audit and Reduction of Industrial Emissions and Wastes: *Technical Report No. 7* [1991] UNEP/UNIDO. 127pp.

Monitoring of Industrial Emissions and Wastes: *Technical Report No. 27* [1996] UNEP/UNIDO. 188pp.

Energy, Efficiency and Climate Change [1991] UNEP/IPIECA. 95pp.

Hazard Identification and Evaluation in a Local Community: *Technical Report No. 12* [1992] 86pp.

Health Aspects of Chemical Accidents: guidance on chemical accident awareness, preparedness and response for health professionals and emergency responders *Technical Report No. 19* [1994] A joint IPCS/OECD/UNEP/WHO publication: OECD Environment Monograph No. 81. 47pp.

Environmental Aspects of Industrial Wood Preservation: a technical guide *Technical Report No. 20* [1994] 105pp.

The Textile Industry and the Environment *Technical Report No. 16* [1994] 120pp.

Environmental Management in the Brewing Industry *Technical Report No. 33* [1995] 120pps.
Storage of Hazardous Materials *Technical Report No. 3* [1990]
Companies Organization and Public Communication on Environmental Issues *Technical Report No. 6* [1991] 130pp.
Company Environmental Reporting *Technical Report No. 24* [1994] 118pp.
From Regulations to Industry Compliance: Building Institutional Capabilities *Technical Report No. 11* [1992] 62pp.

Evaluation Form

Cleaner Production in Breweries

As part of the continuing review of this trainers package, we would appreciate your cooperation in answering the following questions. Please return the completed evaluation form to:

UNEP IE, Tour Mirabeau, 39-43 quai André Citroën, 75739 Paris Cedex 15, France
Fax 33 (1) 44 37 14 74.

1 Do you have any suggestions for improvement of the trainers package? How could we improve its readability, contents, practical use, and so on?

2 How was the package useful in preparing your own training activity?

3 Did the background information and transparency set in *Parts III* and *IV* provide you with enough information? What was missing?

continued …

4 What resource information was useful to you? What else should be included?

5 What are your experiences with the exercises in *Part V*? What worked, and what didn't?

6 Do you have training material which could be incorporated into this workbook?

7 What additional topics related to cleaner production would you want to be included in the final version of this workbook?

Thank you for taking the time to complete this evaluation form. Please return the completed form to UNEP IE, Tour Mirabeau, 39-43 quai André Citroën, 75739 Paris Cedex 15, France.