4 Cleaner Production Assessment

4.1 Cleaner Production Assessment Methodologies

4.1.1 UNEP/UNIDO Methodology

Cleaner Production *assessment* is one of the specific Cleaner Production diagnostic tools. This is a systematic procedure for the identification and evaluation of Cleaner Production options for the companies that are launching a Cleaner Production project. The methodology allows us to identify areas of inefficient use of resources and poor management of wastes in production.

Many organisations have produced manuals describing Cleaner Production assessment methodologies with the same underlying strategies. Table 4.1 lists some of the documents described in the more common methodologies. This chapter will follow the UNEP/UNIDO Cleaner Production assessment methodology [UNEP, 1996a]. The five phases in this methodology correspond to sections 2-6 in the chapter. An overview of the methodology, is therefore found in the box of the chapter content on this page.

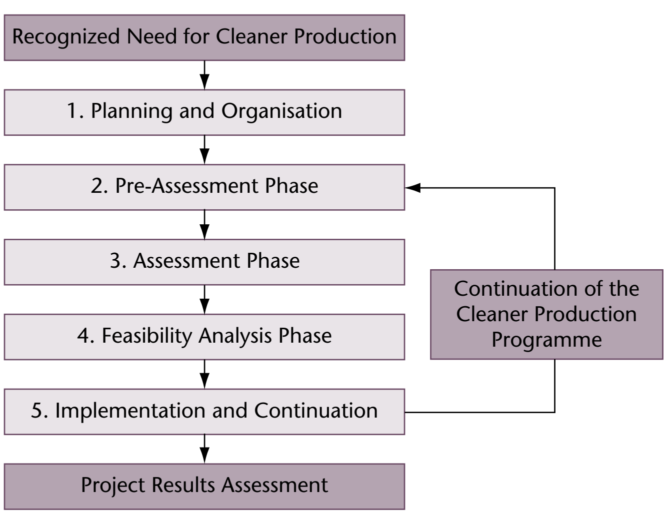

Figure 4.1 *Overview of the Cleaner Production assessment methodology [UNEP, 1996a].*

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A Cleaner Production Assessment and an Environmental Management System (EMS), are comparable. While Cleaner Production projects have a technical orientation, an environmental management system focuses on setting a management framework. It will be obvious from this chapter that a CP assessment needs a solid management structure, just as it is clear that an EMS needs a technical component when it is implemented.

4.2 Planning and Organising Cleaner Production

The objective of this phase is to obtain commitment to the project, allocate resources and plan the details of the work to come.

4.2.1 Obtain Management Commitment

Experiences from many companies show that Cleaner Production initiatives results in both environmental improvements and better economic performance. However, this should be recognised by the management of the company. One of the most effective ways for the management to see the benefits of implementation of Cleaner Production is by example of similar companies which already implemented CP programmes. Several sources for study cases around the world are found in the Internet addresses for this chapter.

4.2.2 Establish a Project Team

The CP project team undertakes the following tasks:

- Analysis and review of present practices.
- Development and evaluation of proposed Cleaner Production initiatives.
- Implementation and maintenance of agreed changes.

The project team should consist of people responsible for the business functions of the major facilities in the company, research & development staff as well as expert consultants in order to facilitate team activities. Members from outside the company would give an independent point of view to Cleaner Production activities.

4.2.3 Develop Environmental Policy, Objectives and Targets

The environmental policy outlines the guiding principles for the assessment. The policy contains the company's mission and vision for continuous environmental improvement and compliance with legislation. The objectives describe how the company will do this. For example, the objectives could include reducing the consumption of materials and minimising the generation of waste. Targets are used to monitor if the company is proceeding as planned. An example of a target might be a 20% reduction in electricity consumption within 2 years. In general, objectives and targets should be:

- Acceptable to those who work to achieve them.
- Flexible and adaptable to changing requirements.
- Measurable over time.
- Motivational.
- In line with the overall policy statement.

4.2.4 Plan the Cleaner Production Assessment

The project team should draw up a detailed work plan and a time schedule for activities within the Cleaner Production assessment. Responsibilities should be allocated for each task so that staff involved in the project understands clearly what they have to do.

Table 4.1 *Methodologies for undertaking a Cleaner Production assessment [CECP, 2001].*

Organisation	Document	Methodology
UNEP, 1996	Guidance Materials for the UNEP/UNIDO National Cleaner Production Centres	1. Planning and organisation 2. Pre-assessment 3. Assessment 4. Evaluation and feasibility study 5. Implementation and continuation
UNEP, 1991	Audit and Reduction Manual for Industrial Emissions and Wastes. Technical Report Series No. 7	1. Pre-assessment 2. Material balance 3. Synthesis
Dutch Ministry of Economic Affairs, 1991	PREPARE Manual for the Prevention of Waste and Emissions	1. Planning and organisation 2. Assessment 3. Feasibility 4. Implementation
US EPA, 1992	Facility Pollution Prevention Guide	1. Development of pollution prevention programme 2. Preliminary assessment

4.3 Pre-assessment

The objective of the pre-assessment is to obtain an overview of the production and environmental aspects of a company. Production processes are best represented by a flow chart showing inputs, outputs and environmental problem areas.

4.3.1 Company Description and Flow Chart

A description of the company's processes should answer the following questions:

- What does the company produce?
- What is the history of the company?
- How is the company organised?
- What are the main processes?
- What are the most important inputs and outputs?

When looking for the answers to the questions the assessment team should first try to find already existing operational data such as production reports, audit reports and site plans. A checklist (Box 4.1) would make this step more comprehensive.

Where information is not available the project team should set up a plan how to obtain the missing data.

The production line to be studied can best be represented using a detailed process flow chart. Producing a flow chart is a key step in the assessment. It will be the basis for material and energy balances which occur later in the assessment. In a process flow chart for a CP assessment, the team should pay particular attention to several activities which are often neglected in traditional process flow charts. These are:

- Cleaning.
- Materials storage and handling.
- Ancillary operations (cooling, steam and compressed air production).
- Equipment maintenance and repair.
- Materials that are not easily recognisable in output streams (catalysts, lubricants etc.).
- By-products released to the environment as fugitive emissions.

The process flow chart is meant to provide an overview and should thus be accompanied by individual input/output sheets for each unit operation or department in the company. Figure 4.2 provides an example of an input/output worksheet.

4.3.2 Walk-through Inspection

Much of the information needed to fill out the input/output sheets, described above, may be obtained during a walk-through inspection of the company. The walk-through inspection should follow the process from start to finish, focusing on areas where products, wastes and emissions are generated.

Case Study 4.1 Management Commitment in ABC Foods AB, Simrishamn

ABC Foods AB is located near Simrishamn, in the south of Sweden, and produces a range of jams and conserves. The plant employs approximately 50 people and supplies wholesalers, for ultimate retail through supermarkets. The plant has a manufacturing capacity of 750,000 kg of jam per year. Apart from the normal range of jams, special recipes are also produced for large users such as bakers, jam tart and pie makers such as the Best Pies Company.

Management Commitment

Over the past few years, the Plant Engineer had implemented a number of process and operations improvement programmes, including upgrading some of the equipment. The Plant Engineer then wanted to formalise an overall assessment of operations to identify opportunities for savings through waste minimisation and process optimisation.

Because such an assessment would involve all departments of ABC Foods, he approached the Managing Director to seek approval to proceed with the idea. The Managing Director complemented the Plant Engineer on his initiative, and was enthusiastic about the concept of a Cleaner Production Programme.

They discussed the basic approach and agreed on the following:

- All departments would be involved in the project and a Cleaner Production Team would be formed, coordinated by the Plant Engineer. The Team would identify, investigate and evaluate cleaner production options. There should be regular reports to the Managing Director to keep him in touch with progress.
- All cost-effective proposals (with less than two-year pay back) would be budgeted for in the following financial year.

The Managing Director wrote a Memo to all staff expressing his commitment to the project, and asked all departments to provide the Plant Engineer with support and assistance. He also called a meeting of all department heads, to explain the project and to seek their commitment. The Plant Engineer made a presentation at this meeting.

Source: NSW-DSRD/NSW-EPA, 2000.

Box 4.2 provides examples of the types of questions which the team may ask operators to facilitate the investigation. During the walk-through all obtained information should be listed, and if there are obvious solutions to the existing problems, they should be noted. Special attention should be paid to no-cost and low-cost solutions. These should be implemented immediately, without waiting for a detailed feasibility analysis.

4.3.3 Establish a Focus

The last step of the pre-assessment phase is to establish a focus for further work. In an ideal case all processes and unit operations should be assessed. However time and resource constraints may make it necessary to select the most important aspects or process areas. It is common for Cleaner Production assessments to focus on those processes that:

Box 4.1 Checklist for Background Information

Type of information	Available	Not available	Requires updating	Not applicable
Process Information				
Process flow diagram				
Material balance data				
Energy balance data				
Site plans				
Drainage diagrams				
Operating procedures*				
Equipment list & specifications				
Regulatory Information				
Waste license(s)				
Trade waste agreement(s)				
Environmental monitoring records				
EPA license(s)				
Environmental audit reports				
Raw Material/Production Information				
Material safety data sheets				
Product & raw material inventories				
Production schedules				
Product composition & batch sheets				
Accounting Information				
Waste handling, treatment & disposal costs				
Water & sewer costs				
Product, energy & raw material costs				
Operating & maintenance costs				
Insurance costs				
Benchmarking data				

** Note whether the plant is ISO 9001 or ISO 14001 certified.*

Source: NSW-DSRD/NSW-EPA, 2000.

Inputs	Process	Outputs
Raw materials:	Department:	Product:
Ancillary materials:	Process:	By-products:
Hazardous materials:		Air emissions:
Water:	Short description:	Solid waste:
Energy:		Hazardous waste:
	Occupational health and safety:	Wastewater discharge:

Figure 4.2 *Example of an input/output worksheet [NSW-DSRD/NSW-EPA, 2000].*

- Generate a large quantity of waste and emissions.
- Use or produce hazardous chemicals and materials.
- Entail a high financial loss.
- Have numerous obvious Cleaner Production benefits.
- Are considered to be a problem by everyone involved.

For example, in order to meet new effluent regulations for chromium discharge, a tannery has to upgrade several aspects of its operation. In this case the assessment should focus on the chromium effluent problem.

All information collected during the pre-assessment phase should be well organised so that it is easily accessed and updated.

4.4 Assessment

The aim of the assessment phase is to collect data and evaluate the environmental performance and production efficiency of the company. Data collected about management activities can be used to monitor and control overall process efficiency, set targets and calculate monthly or yearly indicators. Data collected about operational activities can be used to evaluate the performance of a specific process.

4.4.1 Collection of Quantitative Data

It is important to collect data on the quantities of resources consumed and wastes and emissions generated. Data should be represented based on the scale of production. Collection and evaluation of data will most likely reveal losses. For instance, high electricity consumption outside production time may indicate leaking compressors or malfunctioning cooling systems. Input/output worksheets are useful documents in determining what data to collect. Most data will already be available within the company's recording systems, e.g. stock records, accounts, purchase receipts, waste disposal receipts and production data.

Box 4.2 Walk-through Inspection

Questions to be answered during a walk-through inspection:

- Are there signs of poor housekeeping?
- Are there noticeable spills or leaks? Is there any evidence of past spills, such as discolouration or corrosion on walls, work surfaces, ceilings and walls or pipes?
- Are water taps dripping or left running?
- Are there any signs of smoke, dirt or fumes to indicate material losses?
- Are there any strange odours or emissions that cause irritation to eyes, nose or throat?
- Is the noise level high?
- Are there open containers, stacked drums, or other indicators of poor storage procedures?
- Are all containers labelled with their contents and hazards?
- Have you noticed any waste and emissions being generated from process equipment (dripping water, steam, evaporation)?
- 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?

Source: NSW-DSRD/NSW-EPA, 2000.

Where information is not available, estimates or direct measurements will be required.

4.4.2 Material Balance

The purpose of undertaking a material balance is to account for the consumption of raw materials and services that are consumed by the process, and the losses, wastes and emissions resulting from the process. A material balance is based on the principle of "what comes into a plant or process must equal what comes out". Ideally inputs should equal outputs, but in practice this is rarely the case, and some judgment is required to determine what level of accuracy is acceptable.

Simply expressed, material or mass balance calculations are based on the following equation:

Total material in = material out (product)
+ material out (wastes)
+ material out (emissions)
+ material accumulated

Box 4.3
Sources of Material Balance Information

1. Samples, analyses, and flow measurements of feed stocks, products, and waste streams.
2. Raw material purchase records.
3. Material inventories.
4. Emission inventories.
5. Equipment cleaning and validation procedures.
6. Batch make-up records.
7. Product specifications.
8. Design material balance.
9. Production records.
10. Operating logs.
11. Standard operating procedures and operating manuals.
12. Waste manifests.

Source: UNEP, 1996a.

A material balance makes it possible to identify and quantify previously unknown losses, wastes or emissions, and provide an indication of their sources and causes. Material balances are easier, more meaningful and more accurate when they are undertaken for individual unit operations. An overall company-wide material balance may then be constructed using these partial balances. The material balance sheets can also be used to identify the costs associated with inputs, outputs and identified losses. Presenting these costs to the management of the company often result in a speedy implementation of Cleaner Production options.

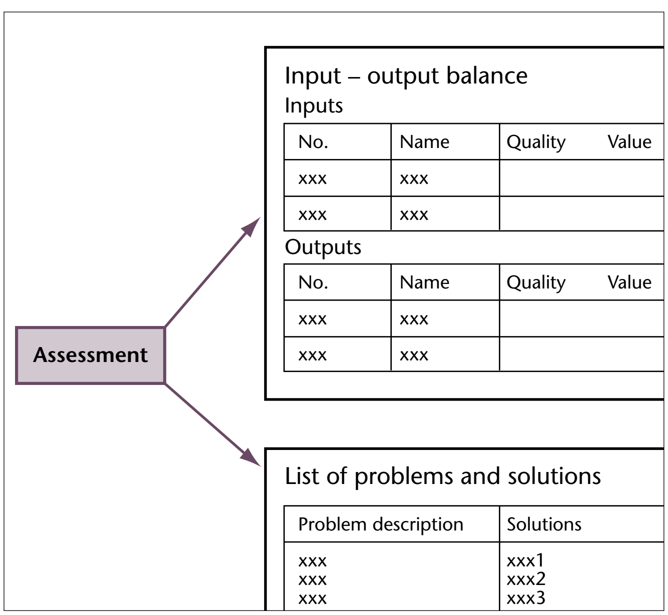


Figure 4.3 *Assessment [UNEP, 1996a].*

Box 4.3 lists the potential sources of material balance information.

While it is complicated to present a complete methodology for establishing a material balance, the following guidelines may be useful:

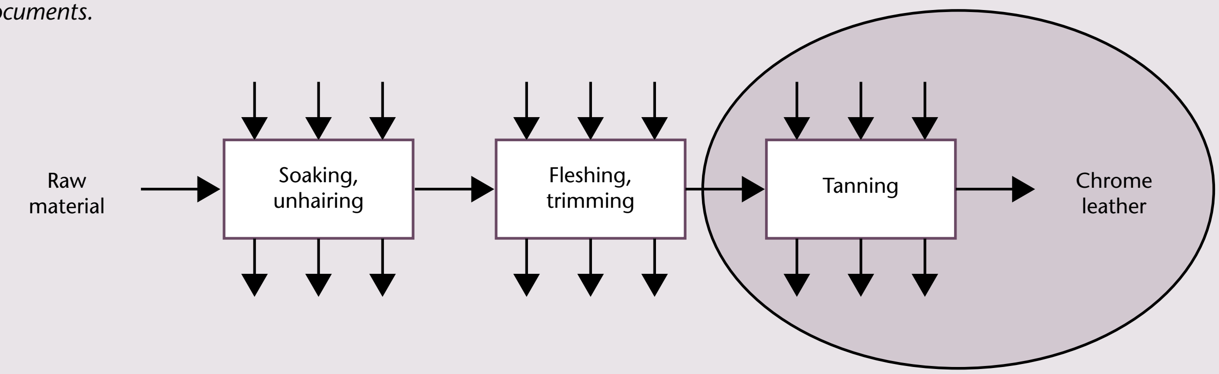
- Prepare a process flow chart for the entire process, showing as many inputs and outputs as possible.
- Sub-divide the total process into unit operations. Sub-division of unit operations should occur in such a way that there is the smallest possible number of streams entering and leaving the process.
- Do not spend a lot of time and resources trying to achieve a perfect material balance; even a preliminary material balance may reveal plenty of Cleaner Production opportunities.

Environmental performance indicators for the process can be developed from the material balance data. This is achieved by dividing the quantity of a material input or waste stream by the production over the same period. Performance indicators may be used to identify over consumption of resources or excessive waste generation by comparing them with those of other companies or figures quoted in the literature. They also help the company track its performance towards its environmental targets.

It is important to determine the true source of the waste stream. Impurities from an upstream process, poor process control, and

Case Study 4.2 Material Balance for Tanning in Leather Treatment

This example focuses on the constructing of material balance for the tanning process in leather treatment technology. *Please note that the figures used in this exercise do not represent a real situation. They are ball park figures drawn from various documents.*



Process inputs

Inputs and water usage:

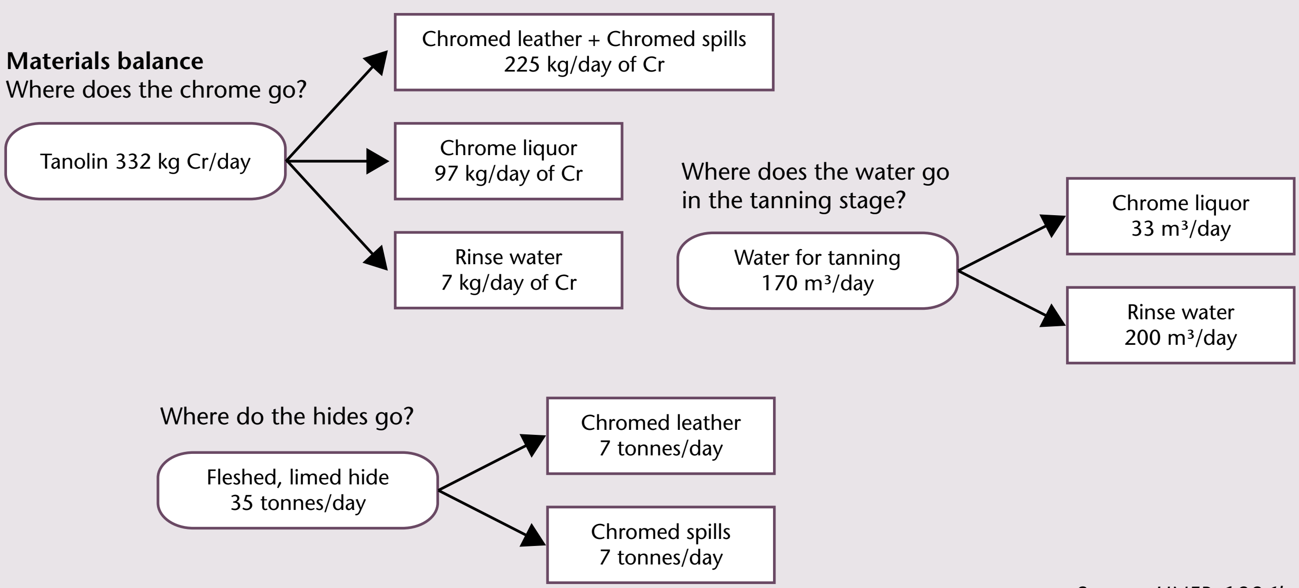
Hides processed	40 tonnes/day
Process water (tannage)	30 m³/day
Rinse water (tannage)	140 m³/day
Total plant water	1800 m³/day
Tanolin (16% Cr)	2076 kg/day
	(322 kg Cr/day)
	(8 kg Cr/tonne of hides)

Waste reuse/recycling:

There is no recycling of waters or solids.
Expected absorption rate of Tanolin is 70% (i.e. 30% is wasted).

Process outputs

Chrome leather	7 tonnes/day
Trimmings and shavings	7 tonnes/day
(Containing together	*225 kg Cr/day)*
Tanning liquors	33 m³/day
	90 kg Cr/day
Tanning rinse waters	200 m³/day
	7 kg Cr/day
Total plant wastewater	1800 m³/day



Source: UNEP, 1996b.

other factors may combine to contribute to waste. Unless these sources are identified and their relative importance established, the generation of Cleaner Production options is too limited. It may focus on a piece of equipment that emits the waste stream but produces only a small part of the waste.

In the example shown in Figure 4.4 the waste stream has four sources. Two of these sources are responsible for about 97% of the waste. However, because these sources were not identified beforehand, roughly equal numbers of options address all four sources. Fortunately, the causes of the waste stream were understood before the assessment was complete. But knowing the major sources of the waste beforehand would have saved time by allowing members to concentrate on them.

Depending on the findings in the initial assessment, the team may see the need to know more about specific details of wastes or energy use. This is done by conducting a detailed audit.

4.4.3 Identify Cleaner Production Opportunities

The Cleaner Production assessment phase starts with making a "diagnosis" of the process to identify shortcomings and their causes, as well as to find options for how to improve it (Figure 4.5). The assessment team uses all means possible to identify Cleaner Production options. Ideas may come from:

- Literature.
- Personal knowledge.
- Discussions with suppliers.
- Examples in other companies.

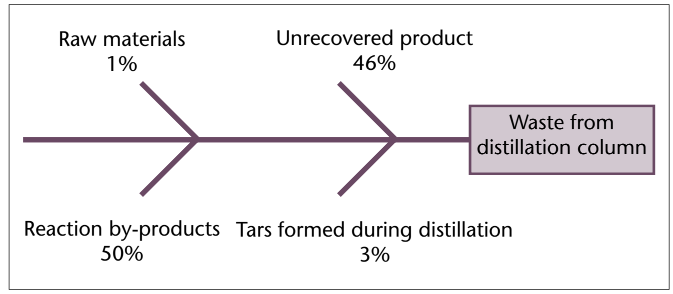


Figure 4.4 *Fishbone analysis of waste sources [UNEP, 1996a].*

- Specialised databases.
- Further research and development.

It should be noted that during the assessment process, a number of obvious possibilities for immediate improvements may already have been identified. For example one of the simplest and obvious measures is reduction in water use or energy use.

One way to produce ideas for Cleaner Production opportunities is to run a brainstorming session. Brainstorming sessions have proved to be most effective when managers, engineers, process operators and other employees as well as some outside consultants, work together without hierarchical constraints.

Many Cleaner Production solutions are arrived at by carefully analysing the cause of a problem. Often the temptation is to jump from identifying where wastes and emissions are

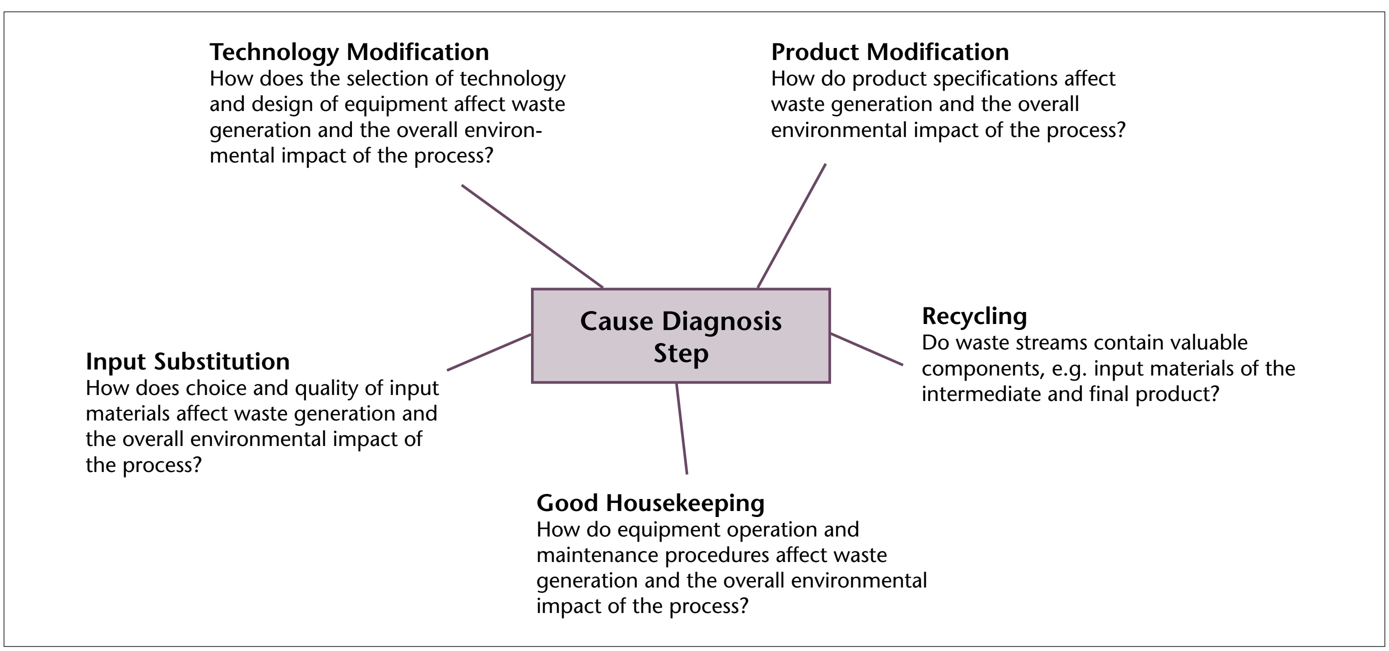


Figure 4.5 *Cause diagnosis [UNEP/DEPA, 2000].*

being generated directly to coming up with solutions how to prevent them. However, adding a middle diagnostic step is often a good idea. It provides additional information, which complements the Cleaner Production options. Five key areas of diagnosis of the causes are described in Figure 4.5.

Secondly the team focuses on Cleaner Production prevention practices. Here it is important to keep in mind that there are five features which influence the process, and which can serve as focus points for generating options:

1. Input materials.
2. Technology.
3. Execution of the process.
4. Product.
5. Waste and emissions.

Based on these five features that influence the environmental performance of a process, the corresponding points of action can be used to improve the environmental performance of the process (Figure 4.6). These are:

1. Input material changes or input substitution.
2. Technology changes or technology modifications.
3. Good housekeeping or good operating practices.
4. Product changes or product modifications.
5. Recycling.

We will briefly comment on each one of these in the following.

Input material changes may contribute to Cleaner Production by reducing or eliminating hazardous materials that enter the production process. Also, changes in input materials can be made to avoid the generation of hazardous wastes within the production processes. Input material changes are either material purification or material substitution.

Technology changes are oriented toward process and equipment modifications to reduce waste, primarily in a production setting. Technology changes range from minor alterations that are possible to implement in a matter of days at low costs, to the replacement of processes involving large capital costs. These may be changes in the production process; introducing new equipment, layout, or piping changes; introducing the use of automation; and implementing changes in process conditions such as flow rates, temperatures, pressures and residence times.

Good housekeeping implies procedural, administrative, or institutional measures that a company can use to minimise waste. Many of these measures are used in larger industries as efficiency improvements and good management practices. Good housekeeping practices can often be implemented in all areas of the plant, including production, maintenance operations, and raw material and product storage. Good housekeeping or operating practices include the following:

- Cleaner Production programmes, as described in this chapter.
- Management and personnel practices, including employees training, incentives and bonuses, and other

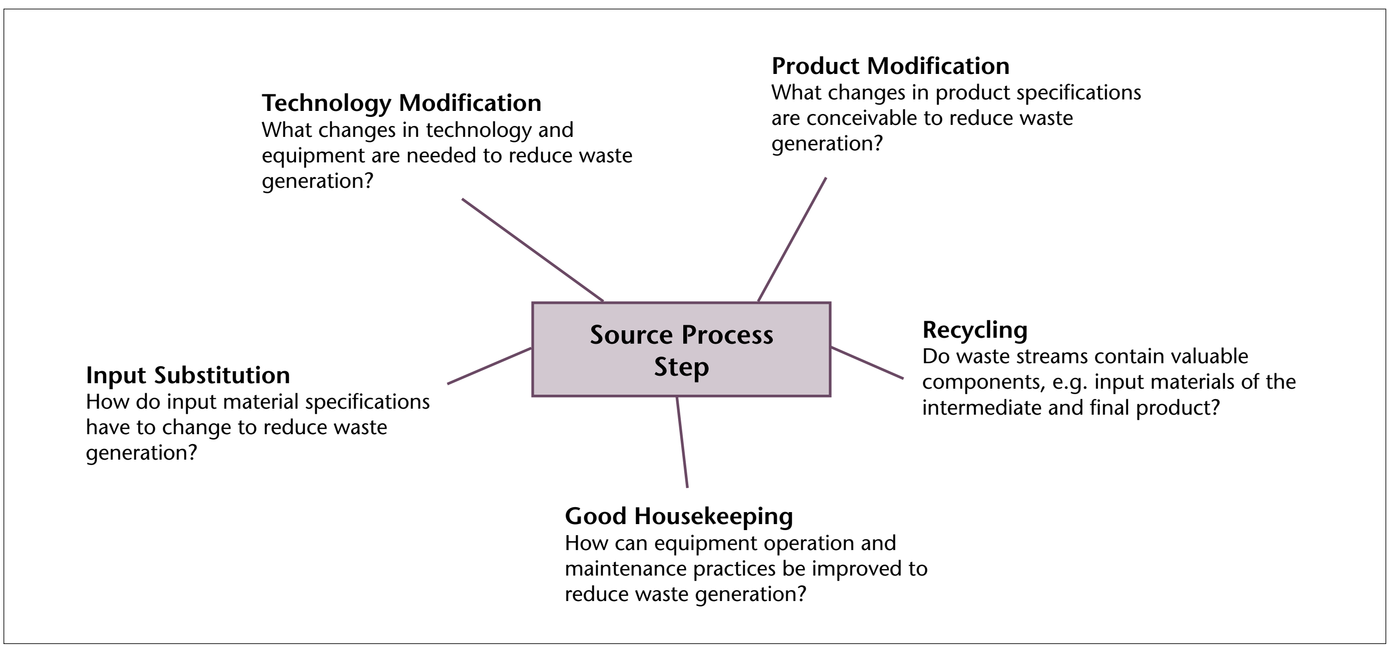


Figure 4.6 *Cleaner Production prevention practices [UNEP/DEPA, 2000].*

programmes that encourage employees to conscientiously work to reduce waste.

- Material handling and inventory practices, including programmes to reduce loss of input materials due to mishandling, expired shelf life of time-sensitive materials, and proper storage conditions.
- Loss prevention, minimising wastes by avoiding leaks from equipment and spills.
- Waste segregation, reducing the volume of hazardous wastes by preventing the mixing of hazardous and non-hazardous wastes.
- Cost accounting practices, including programmes to allocate waste treatment and disposal costs directly to the department or groups that generate waste, rather than charging these costs to general company overhead accounts. In doing so, the departments or groups that generate the waste become more aware of the effects of their treatment and disposal practices, and have a financial motivation to minimise their waste.
- Production scheduling, and scheduling batch production runs. This way the frequency of equipment cleaning and the resulting waste can be reduced. It is at this stage also that the energy efficiency of the process, and of the general plant operations, can be considered.

Product changes are performed by the manufacturer of a product with the intent of reducing waste resulting from a product's use. Product changes include:

- Product substitution.
- Product conservation.
- Changes in product composition.

Product modification is about changing the characteristics of a product such as its shape and material composition. Eight groups of strategies have been identified for the reduction of environmental impacts in products, and summarised in the so-called *ecodesign strategy wheel* (Figure 4.7). By working through the categories and mapping them on this ecodesign strategy wheel, a product's environmental improvement options soon become more clear (See Book 3 in this series).

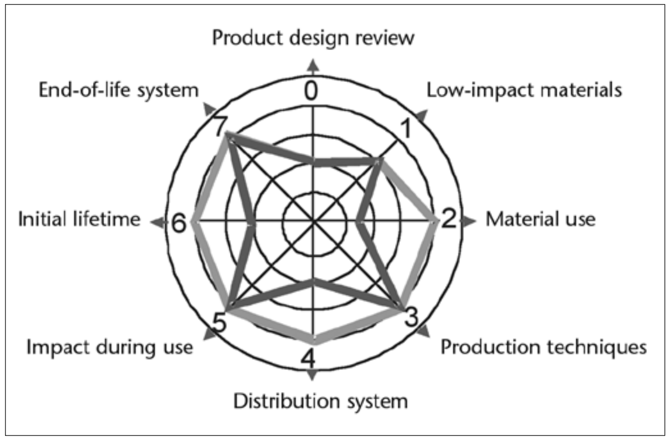


Figure 4.7 *Ecodesign strategy wheel [Hemel and Brezet, 1997 & Van Hemel, 1995].*

Recycling via use and/or reuse involves the return of a waste material either to the originating process as a substitute for an input material, or to another process as an input material.

4.4.4 Record and Sort Options

Once a number of Cleaner Production opportunities have been suggested and recorded, they should be sorted into those that can be implemented directly and those that require further investigation. It is helpful to follow the steps:

- Organise the options according to unit operations or process areas, or according to inputs/outputs categories (e.g. problems that cause high water consumption).
- Identify any mutually interfering options, since implementation of one option may affect the other.
- Opportunities that are cost free or low cost, that do not require an extensive feasibility study, or that are relatively easy to implement should be implemented immediately.
- Opportunities that are obviously infeasible, or cannot be implemented should be eliminated from the list of options for further study.

Table 4.2 *Example of information recorded for identified options [UNEP, 1996a].*

Problem type	Problem description	Cleaner Production Options
- resource consumption - energy consumption - air pollution - solid waste - wastewater - hazardous waste - occupational health and safety	- name of process and department - short background of problem - amount of materials lost or concentration of pollutants - money lost due to lost resources	- how the problem can be solved - short-term solution - long-term solution - estimated reductions in resource consumption and waste generation

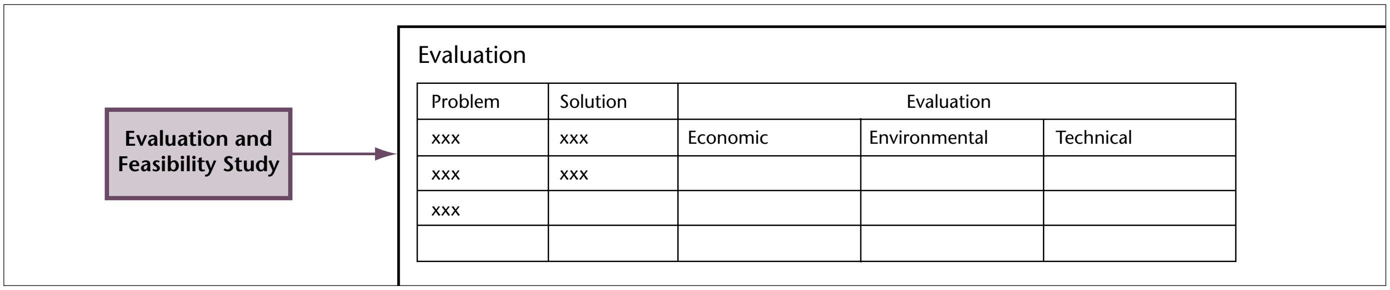


Figure 4.8 *Evaluation and feasibility study phase [UNEP, 1996a].*

4.5 Evaluation and Feasibility Study

The objective of the evaluation and feasibility study phase is to evaluate the proposed Cleaner Production opportunities and to select those suitable for implementation. The opportunities selected during the assessment phase should all be evaluated according to their technical, economic and environmental merits. However, the depth of the study depends on the type of project. Complex projects naturally require more thought than simple projects.

4.5.1 Preliminary Evaluation

The quickest and easiest method of evaluating the different options is to form a group, consisting of the project team and management personnel, and discuss the possible solutions one by one. This process should give a good indication of which projects are feasible and what further information is required.

4.5.2 Technical Evaluation

The potential impacts on products, production processes and safety concerns of the proposed changes need to be evaluated before complex and costly projects can be decided upon. In addition, laboratory testing or trial runs may be required when options significantly change existing practices. A technical evaluation will determine whether the opportunity requires staff changes or additional training or maintenance. An example is described in Case Study 4.3.

4.5.3 Economic Evaluation

The objective of this step is to evaluate the cost effectiveness of the Cleaner Production opportunities. Economic viability is often the key parameter that determines whether or not an opportunity will be implemented.

Case Study 4.3 An Example of Technical Evaluation

An insulation manufacturer came up with an option to replace the main raw material for its primary product with another material. The following table shows a before and after comparison, forming part of the technical evaluation.

Consumption rates	Before implementation	After implementation
Main raw material in solid waste	120 tonnes/year	0 tonnes/year
Resin fumes	5 m^3/year (estimated)	0/year
Energy		>50% reduction (no extraction equipment used to remove fumes, no heating of raw material required)
Reject products (in solid waste)	7.5% of product	1% of product
Transport		Reduced for main raw material as it is lighter and less bulky
Storage		Reduced for main raw material as it is lighter and less bulky
Productivity		>200% improvement, ie takes less than half the time to process new raw material
Product cost		Reduced due to lower cost of main raw material

Source: CECP, 2001.

Case Study 4.4 Calculation of the Net Present Value (NPV) for a CP Investment in a Tannery

A tannery considers spending USD 351,120 for the installation of four special drums in order to use Cleaner Production process for un-hairing hides.

Yearly savings will be USD 87,780 in reduced chemical costs. The pay back period is therefore 4 years.

The tannery will need to borrow money in order to fund this project. The interest rate for the loan is 8.5%.

The loan will be for the full USD 351,120 investment and will be for a four-year term. The NPV is then USD 63,557.

As the NPV is positive, the project is financially viable. If the drums have a longer life time than 4 years the NPV will increase by USD 87,780 each additional year.

Source: UNEP, 1996b.

$$NPV = -351120 + \frac{87780}{(1+0.085)^1} + \frac{87780}{(1+0.085)^2} + \frac{87780}{(1+0.085)^3} + \frac{87780}{(1+0.085)^4} = 63557$$

When performing the economic evaluation, costs of the change are weighed against the savings that may result. Costs can be broken into capital investments and operating costs.

Investment capital estimates can be broadly classified in three types according to the accuracy and purpose of the estimate.

1. Preliminary feasibility estimates are used for initial feasibility studies and to make rough choices between design alternatives. The accuracy of theses estimates is in the order of ± 30%. *Feasibility estimates* are often made on capital cost information for a complete process taken from previously built plants. The cost information is adjusted using scaling factors for capacity and for inflation to obtain the estimated capital cost.

$$C_2 = C_1 (S_2/S_1)n$$

where
C_1 = capital cost of the project with capacity S_1.
C_2 = capital cost of the project with capacity S_2.
n = cost factor. The empirical value for process plants, for individual units of equipment the value varies from ca 0.3 to 0.8.

Major equipment estimates provide more accurate (± 30%) capital estimates. In this method all major process equipment is roughly sized and the approximate purchased equipment cost is calculated. The total cost of the equipment is then factored for installation, piping, instrumentation, electrical installations, utilities, buildings, foundations etc. to give the total estimated process cost. The so called Lang factor for a mixed fluids-solids processing plant indicates that the total capital investment is 3.6 times the cost of the major process equipment.

2. Budget (or Authorisation) estimates, with accuracy of ± 10-15%, are used for authorisation of funds to proceed with the design to the point where a more accurate estimate can be

Box 4.4
Aspects to be Considered in the CP Evaluation

Preliminary evaluation

- Is the Cleaner Production option available?
- Can a supplier be found to provide the necessary equipment or input material?
- Are consultants available to help develop an alternative?
- Has this Cleaner Production opportunity been applied elsewhere? If so, what have been the results and experience?
- Does the option fit in with the way the company is run?

Technical evaluation

- Will the option compromise the company's product?
- What are the consequences for internal logistics, processing time and production planning?
- Will adjustments need to be made in other parts of the company?
- Does the change require additional training of staff and employees?

Economic evaluation

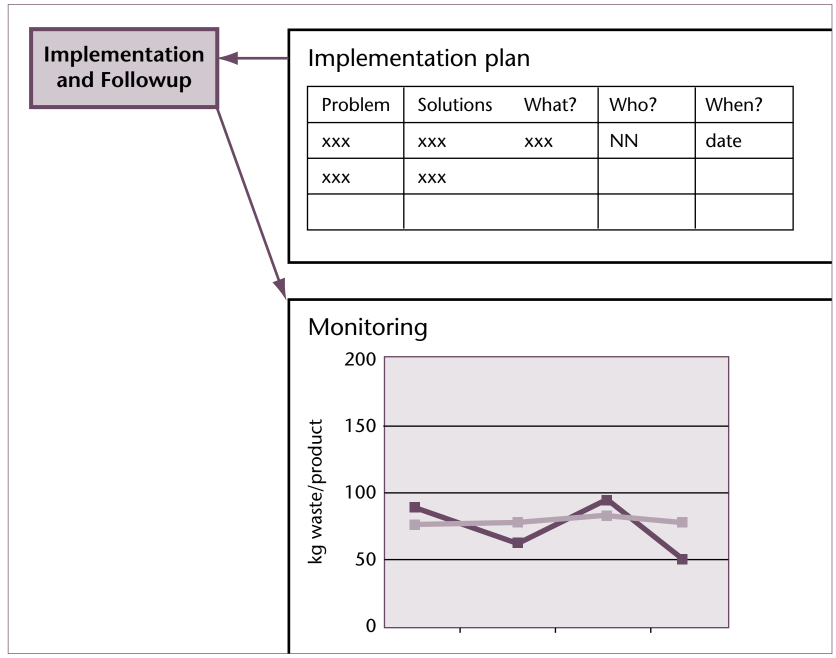
- What are the expected costs and benefits?
- Can an estimate of required capital investment be made?
- Can an estimate of the financial savings be made, such as reductions in environmental costs, waste treatment costs, material costs or improvements to the quality of the product?

Environmental evaluation

- What is the expected environmental effect of the option?
- How significant is the estimated reduction in wastes or emissions?
- Will the option affect public or operator health (positive or negative)? If so, what is the magnitude of these effects in terms of toxicity and exposure?

Source: CECP, 2001.

Figure 4.9 *Implementation and continuation phase [CECP, 2001].*



made. This type of estimate requires preliminary specifications of all the equipment, utilities, instrumentation, electrical and off-site installations of the process.

3. Detailed (Quotation) estimates, accuracy ± 5-10%, are used for project cost control and for contractor negotiations. This type requires complete, detailed process design, firm quotations for equipment and detailed breakdown and estimation of construction cost.

Operating costs include *direct manufacturing costs* such as raw materials, waste treatment, utilities, labour costs, maintenance and repairs, *fixed manufacturing costs* which include capital costs (interest), depreciation of the installed equipment, taxes, insurance and plant overhead costs. The operating costs also include *general costs* shared with other parts of the company such as administration, distribution and sales costs and costs for research and development.

Standard parameters used to evaluate the economic feasibility of a project are pay back period, net present value (NPV), or internal rate of return (IRR).

As an example we can take a tannery, which will have to spend USD 351,120 for the installation of four special drums in order to use a Cleaner Production process for un-hairing hides, rather than using a chemical method. The annual savings is estimated to be USD 87,780 in reduced chemical costs. The pay back period is therefore 4 years.

A more accurate evaluation of the financial viability of a project is obtained by calculating its net present value (Case Study 4.4). The NPV is calculated using the formula.

$$NPV = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \dots + \frac{CF_n}{(1+r)^n}$$

CF_x =cash flow in period x, n=the number of periods (normally the expected lifetime of the project).
r=the discount rate.
CF_0 =investment cost, which will be negative as it is money paid out.

Choosing the correct discount rate is a very important part of any NPV calculation. As it is essentially an interest rate, there are two basic ways of selecting which rate to use.

- If you are going to borrow capital to implement the project you can simply use the interest rate you will be charged on the loan.
- If you will not take a loan to fund the project, use the interest rate you would receive if you were to invest the money.

Most companies will add a small risk margin of 2-5% to the discount rate, for example, in case interest rates go up. If you are taking a loan, you may also want to take into account the effect on the discount rate of the tax deductions allowable on interest payments for business loans.

The IRR method is evaluating projects in the opposite way to the NPV method. It enables you to calculate the interest rate equivalent to the return expected from the project over its lifetime. When this rate is known, it can be compared to the rates you would receive if you invested the money elsewhere. Generally, if the IRR is higher than cost for a loan, then the project is financially viable.

Calculation of IRR is based on the same equation as NPV, but now the equation is solved for r.

$$0 = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \dots + \frac{CF_n}{(1+r)^n}$$

The capital investment is the sum of the fixed capital costs of design, equipment purchase, installation and commissioning, costs of working capital, licenses, training, and financing. Operating costs, if different from existing conditions, will need to be calculated. It may be that operating costs are reduced as a result of the change. In this case it should be accounted for in the evaluation as an ongoing savings.

4.5.4 Environmental Evaluation

The objective of the environmental evaluation is to determine the positive and negative environmental impacts of the proposed Cleaner Production option. In many cases the environmental advantages are obvious: a net reduction in toxicity and/or quantity of wastes or emissions. In other cases it may be necessary to evaluate whether an increase in electricity consumption, for instance, would outweigh the environmental advantages of reducing the consumption of materials.

For a good environmental evaluation, the following information is needed:

- Changes in amount and toxicity of wastes or emissions.
- Changes in energy consumption.
- Changes in material consumption.
- Changes in degradability of the wastes or emissions.
- Changes in the extent to which renewable raw materials are used.
- Changes in the reusability of waste streams and emissions.
- Changes in the environmental impacts of the product.

In many cases it will be impossible to collect all the data necessary for a good environmental evaluation. In such cases a qualified assessment will have to be made on the basis of the existing information. Given the wide range of environmental issues, it will probably be necessary to prioritise those issues of greatest concern. In line with the national environmental policy of the country or the company, some issues may have a higher priority than others.

4.5.5 Select Viable Options

The most promising options must be selected in close collaboration with the management of the company.

A comparative ranking analysis may be used to prioritise opportunities for implementation. The concept of such a method is shown below in Table 4.3. An option can be assigned scores, say from 1 to 10, based on its performance against a set of evaluation criteria. By multiplying each score by a relative weight assigned to each criterion, a final score can be arrived at. The options with the highest scores will probably be best suited for implementation. However, the results of this analysis should not be blindly accepted. Instead, they should form a starting point for a discussion. All simple, cost-free and low-cost opportunities should of course be implemented as soon as possible.

4.6 Implementation and Continuation

The objective of the last phase of the assessment is to ensure that the selected options are implemented, and that the resulting reductions in resource consumption and waste generation are monitored continuously.

4.6.1 Prepare an Implementation Plan

To ensure implementation of the selected options, an action plan should be developed, detailing:

Table 4.3 *Example of a weighted sum method for evaluating alternative options [CECP, 2001].*

Evaluation criterion	Weight	Score*					
		Option A		Option B		Option C	
		score	weighed score	score	weighed score	score	weighed score
Reduced hazardous waste treatment	3	+3	9	+2	6	+3	9
Reduced wastewater treatment costs	3	+1	3	0	0	+2	6
Reduced amount of solid waste	3	+3	9	+2	6	+3	9
Reduced exposure to chemicals	2	+3	6	0	0	-1	-2
Reduced amount of water consumption	1	+1	1	0	0	+2	2
Reduced odours problems	1	0	0	-1	-1	0	0
Reduced noise problems	1	-2	-2	0	0	0	0
Easy to install and maintain	3	-1	-3	-1	-3	+1	3
Weighted sum			23		8		27

-3 = lowest rank, 0 = no change, +3 = highest rank (preferred)

- Activities to be carried out.
- The way in which the activities are to carried out.
- Resource requirements (finance and manpower).
- The persons responsible for undertaking those activities.
- A time frame for completion with intermediate milestones.

4.6.2 Implement Selected Options

As for other investment projects, the implementation of Cleaner Production options involves modifications to operating procedures and/or processes and may require new equipment. The company should, therefore, follow the same procedures as it uses for implementation of any other company projects. However, special attention should be paid to the need for training of the staff. The project could be a failure if it is not backed up by adequately trained employees. Training needs should have been identified during the technical evaluation.

4.6.3 Monitor Performance

It is very important to evaluate the effectiveness of the implemented Cleaner Production options. Typical indicators for improved performance are:

- Reductions in wastes and emissions per unit of production.
- Reductions in resource consumption (including energy) per unit of production.
- Improved profitability.

There should be periodic monitoring to determine whether positive changes are occurring and whether the company is progressing toward its targets. Examples of the types of aspects that could be checked to evaluate improvements are shown in Table 4.4.

The most important steps in establishing or upgrading an environmental monitoring system are to agree on the objectives of the system and design the system to address these objectives. Monitoring methodologies for the different pollutants of concern, and monitoring planning are described elsewhere. Case Study 4.5 describes a monitoring and reporting case from an iron and steel manufacturing industry, which is implementing a World Bank pollution-related project.

4.6.4 Sustain Cleaner Production Activities

Sustained Cleaner Production is best achieved when it becomes part of the management through a formal company environ-

Table 4.4 *Evaluation checklist [UNEP, 1996a].*

	YES	NO
Overall Cleaner Production assessment check		
- Are the opportunities implemented according to the action plan?		
- Are new procedures being followed correctly by the employees?		
- Where do problems occur and why?		
- Do licenses or permits require amendments? Which ones?		
- Has compliance with legislation been maintained as a result of the changes?		
Environmental performance check		
- Are the opportunities cost effective? Is the cost effectiveness as expected?		
- Has the number of waste and emission sources decreased? By how many?		
- Has the total amount of waste and emissions decreased? By how much?		
- Has the toxicity of the waste and emissions decreased? By how much?		
- Has the energy consumption decreased? By how much?		
- Have the Cleaner Production goals been achieved? Which have and which have not?		
- Have there been any technical ramifications? What are they and why?		
Documentation check (The following items should be included in the files.)		
- Statements of the company's objectives and targets and the environmental policy		
- Company description and flow diagram with input and outputs		
- Worksheets completed during the Cleaner Production assessment		
- Material balances		
- List of Cleaner Production opportunities generated during brainstorming sessions		
- Lists of opportunities that are technically, economically and environmentally feasible		
- Implementation action plan		
- Monitoring data		
- 'Before-and-after' comparisons		
- Post-implementation evaluation reports		

Case Study 4.5 Environmental Monitoring in an Iron and Steal Manufacturing Plant Implemented as Part of a World Bank Project

Air emissions should be monitored continuously after the air pollution control device for particulate matter (or alternatively an opacity level of less than 10%) and annually for sulphur oxides, nitrogen oxides (with regular monitoring of sulphur in the ores) and fluoride. Wastewater discharges should be monitored daily for the listed parameters, except for metals, which should be monitored at least on a quarterly basis. Frequent sampling may be required during start-up and upset conditions.

Source: The World Bank Group, 1999.

mental management system or a total environmental quality management approach. An environmental management system provides a decision-making structure and action plan to support continuous environmental improvements, such as the implementation of Cleaner Production. If a company has already established an environmental management system, the Cleaner Production assessment can be an effective tool for focusing attention on specific environmental problems. If, on the other hand, the company establishes a Cleaner Production assessment first, this can provide the foundations of an environmental management system.

Abbreviations

DEPA	Danish Environmental Protection Authority.
EMS	Environmental Management System.
EPA	Environmental Protection Authority.
IRR	Internal Rate of Return.
NPV	Net Present Value.
NSW	New South Wales.
PPAH	Pollution Prevention and Abatement Handbook, The World Bank Group.
UNEP	United Nations Environment Programme.
UNIDO	United Nations Industrial Development Organisation.

Study Questions

1. Describe the Cleaner Production assessment methodology of UNEP/UNIDO.
2. How may the implementation of Cleaner Production assessment methodologies in companies give environmental and economic benefits?
3. Which company specialists should be included in a project team for the analysis and review of present practices and development of Cleaner Production initiatives? Which questions should first be considered? Determine the sources of information.
4. What does the material balance mean?
5. How is it possible to accomplish a Cleaner Production programme in a company? Give some examples of good housekeeping in companies, product changes and so on.
6. In which way may the environmental, economic and technical effectiveness of a project be evaluated? Write the formula for calculating the NPV and other methods of evaluation.
7. What should be included in an action plan for Cleaner Production implementation?

Internet Resources

Centre of Excellence in Cleaner Production (CEPE)
http://cleanerproduction.curtin.edu.au

The University of Queensland, Australia, School of Geography, Planning, Architecture – Cleaner Production Programme
http://www.gpa.uq.edu.au/CleanProd/

New South Wales Department of State and Regional Development – Cleaner Production in Small Businesses
http://www.smallbiz.nsw.gov.au/smallbusiness/Technology+in+Business/Cleaner+Production/

United Nations Industrial Development Organisation (UNIDO)
http://www.unido.org/

The International Institute for Industrial Environmental Economics at Lund University
http://www.iiiee.lu.se/

United Nations Environment Programme Division of Technology, Industry, and Economics (UNEP DTIE) – CP Assessment in Industries
http://www.uneptie.org/PC/cp/understanding_cp/cp_industries.htm