

5 CLEANER PRODUCTION ASSESSMENT

A Cleaner Production assessment is a methodology for identifying areas of inefficient use of resources and poor management of wastes, by focusing on the environmental aspects and thus the impacts of industrial processes.

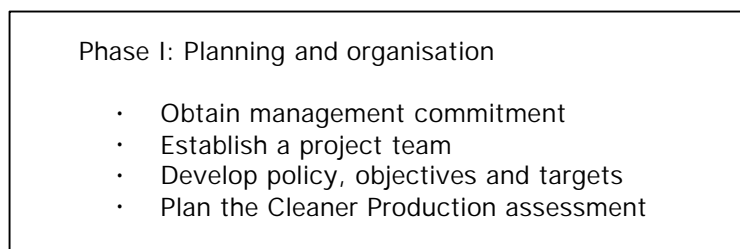
Many organisations have produced manuals describing Cleaner Production assessment methodologies at varying levels of detail. However, the underlying strategies are much the same. The basic concept centres around a review of a company and its production processes in order to identify areas where resource consumption, hazardous materials and waste generation can be reduced. Table 5-1 lists some of the steps described in the more well-known methodologies.

Table 5-1 Methodologies for undertaking a Cleaner Production assessment

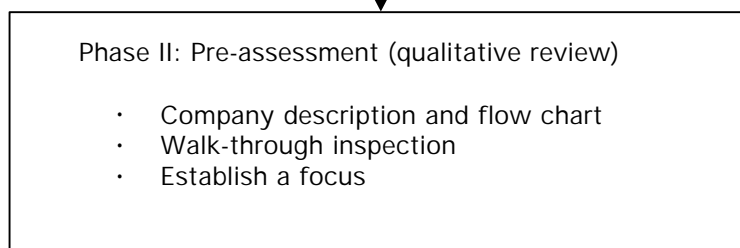
Organisation	Document	Methodology
UNEP, 1996	<i>Guidance Materials for the UNIDO/UNEP National Cleaner Production Centres</i>	<ol style="list-style-type: none"> 1. Planning and organisation 2. Pre-assessment 3. Assessment 4. Evaluation and feasibility study 5. Implementation and continuation
UNEP, 1991	<i>Audit and Reduction Manual for Industrial Emissions and Wastes. Technical Report Series No. 7</i>	<ol style="list-style-type: none"> 1. Pre-assessment 2. Material balance 3. Synthesis
Dutch Ministry of Economic Affairs, 1991	<i>PREPARE Manual for the Prevention of Waste and Emissions</i>	<ol style="list-style-type: none"> 1. Planning and organisation 2. Assessment 3. Feasibility 4. Implementation
USEPA, 1992	<i>Facility Pollution Prevention Guide</i>	<ol style="list-style-type: none"> 1. Development of pollution prevention programme 2. Preliminary assessment

The rest of this chapter describes the steps within a Cleaner Production assessment as outlined in the UNEP/UNIDO document, *Guidance Materials for UNIDO/UNEP National Cleaner Production Centres*. (UNEP, 1995). The steps from this methodology are detailed further in Figure 5—1.

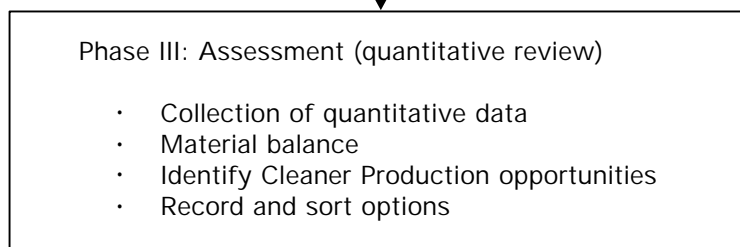
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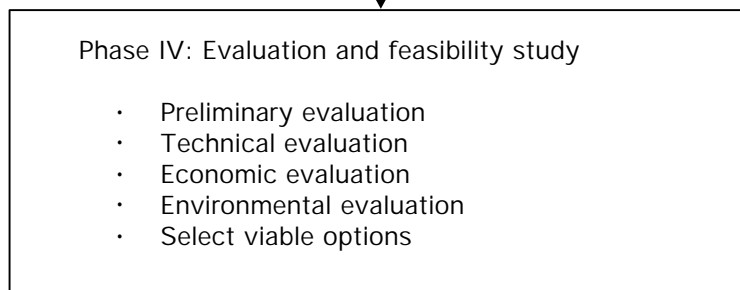
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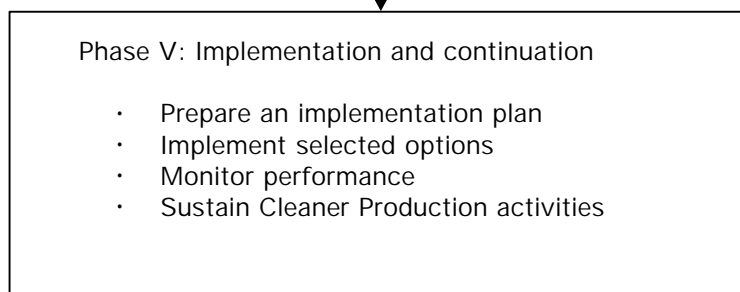


Figure 5—1 Overview of the Cleaner Production assessment methodology (UNEP, 1996)

5.1 Planning and organisation

The objective of this phase is to obtain commitment to the project, initiate systems, allocate resources and plan the details of the work to come. A project has more chance of success if this groundwork is done well.

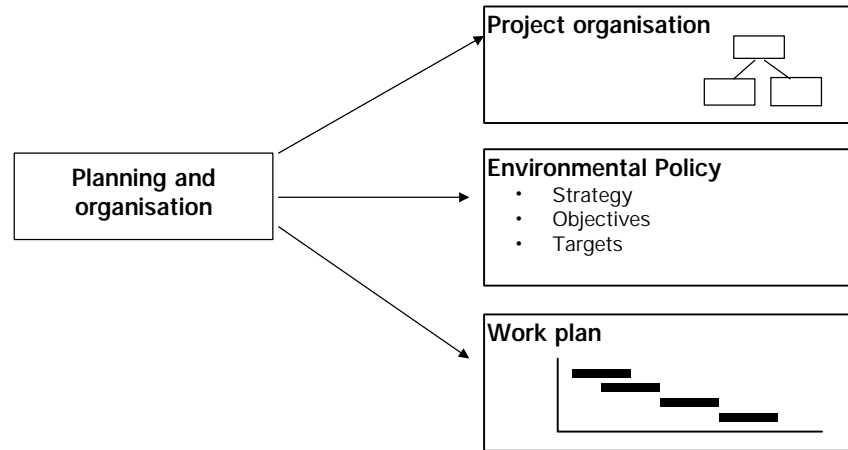


Figure 5—2 Planning and organisation phase

5.1.1 Obtain management commitment

Experience from companies throughout the world shows that Cleaner Production results in both environmental improvements and better economic performance. However, this message has to reach the management of the company. Without management commitment the Cleaner Production assessment may be only a short-term environmental management tool.

5.1.2 Establish a project team

It is best to establish a project team as early in the process as possible. The project team is responsible for progressing the assessment and will normally undertake the following tasks:

- analysis and review of present practices (knowledge);
- development and evaluation of proposed Cleaner Production initiatives (creativity);
- implementation and maintenance of agreed changes (authority).

5.1.3 Develop environmental policy, objectives and targets

The environmental policy outlines the guiding principles for the assessment. It acts to focus efforts in a way considered most important by management. The environmental policy can be refined as the project team gains more insight into the Cleaner Production possibilities within the company.

The policy contains the company's mission and vision for continuous environmental improvement and compliance with legislation. Objectives describe how the company will do this. For example, objectives could include reducing consumption of materials and minimising the generation of waste. Targets are measurable and scheduled, and 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 (targets only);
- motivational;
- in line with the overall policy statement.

5.1.4 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 understand clearly what they have to do. It is also wise to anticipate any problems or delays that may arise and plan for them accordingly. Lengthy delays and problems arising out of poor planning erode motivation at both the worker and management level.

5.2 Pre-assessment

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

5.2.1 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?

Processes which take place as part of the company's activities can be represented using a detailed process flow chart. Flow chart production is a key step in the assessment and forms the basis for material and energy balances which occur later in the assessment. Process flow charts should pay particular attention to activities which are often neglected in traditional process flow charts, such as:

- 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 of providing an overview and should thus be accompanied by individual input/output sheets for each unit operation or department. Figure 5—3 provides an example of an input/output worksheet, however it may be arranged in various ways.

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

Figure 5—3 Example of an input/output worksheet

5.2.2 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, if possible, follow the process from the start to the finish, focusing on areas where products, wastes and emissions are generated. During the walk-through, it is important to talk to the operators, since they often have ideas or information that can be useful in identifying sources of waste and Cleaner Production opportunities. The text box over page provides examples of the types of questions that may be asked to prompt the investigation.

During the walk-through problems encountered along the way should be listed, and if there are obvious solutions to these they should also 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.

5.2.3 Establish a focus

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

- 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.

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

Questions to be answered during a walk-through inspection

Are there signs of poor housekeeping (untidy or obstructed work areas etc.)?

Are there noticeable spills or leaks? Is there any evidence of past spills, such as discoloration 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?

5.3 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.

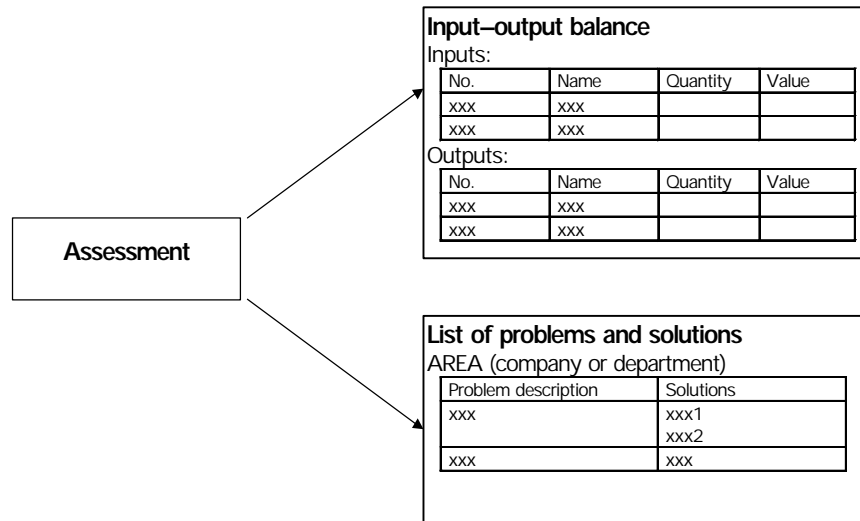


Figure 5—4 Assessment phase

5.3.1 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: for example: water consumption per tonne of live carcass weight (LCW) processed or mass of organic matter (COD) generated per tonne of live carcass weight (LCW) processed. 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.

In determining what data to collect, use the input/output worksheets, described previously, as a guide. Most data will already be available within the company recording systems, e.g. stock records, accounts, purchase receipts, waste disposal receipts and the production data. Where information is not available, estimates or direct measurements will be required.

5.3.2 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.

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 operation. An overall company-wide material balance can then be constructed with these.

The material balance can also be used to identify the costs associated with inputs, outputs and identified losses. It is often found that

presenting these costs to management can result in a speedy implementation of Cleaner Production options.

While it is not possible to lay down a precise and complete methodology for undertaking 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 can 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.

5.3.3 Identify Cleaner Production opportunities

Identifying Cleaner Production opportunities depends on the knowledge and creativity of the project team members and company staff, much of which comes from their experience. Many Cleaner Production solutions are arrived at by carefully analysing the cause of a problem.

Another way of identifying Cleaner Production opportunities is to hold a 'brainstorming' session, where people from different parts of the organisation meet to discuss solutions to specific problems in an open and non-threatening environment.

Some other sources of help from outside the organisation could be:

- this guide;
- external industry personnel or consultants;
- trade associations;
- universities, innovation centres, research institutions, government agencies;
- equipment suppliers;
- information centres, such as UNEP or UNIDO;
- literature and electronic databases.

5.3.4 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 following 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 unfeasible, or cannot be implemented should be eliminated from the list of options for further study.

Table 5—2 Example of information recorded for identified options

Problem type	Problem description	Cleaner Production options
<p>Examples:</p> <ul style="list-style-type: none"> • resource consumption • energy consumption • air pollution • solid waste • wastewater • hazardous waste • occupational health and safety 	<p>Examples:</p> <ul style="list-style-type: none"> • name of process and department • short background of problem • amount of materials lost or concentration of pollutants • money lost due to lost resources 	<p>Examples:</p> <ul style="list-style-type: none"> • how the problem can be solved • short-term solution • long-term solution • estimated reductions in resource consumption and waste generation

5.4 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 merit. However, the depth of the study depends on the type of project. Complex projects naturally require more thought than simple projects. For some options, it may be necessary to collect considerably more information. An important source of this information may be employees affected by the implementation.

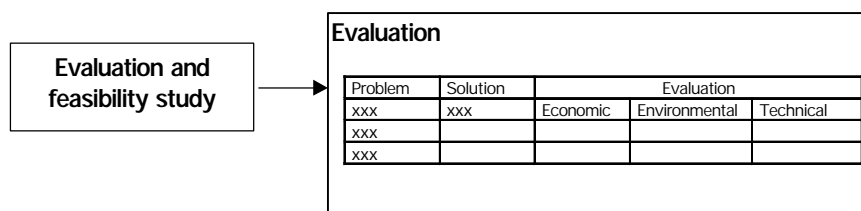


Figure 5—5 Evaluation and feasibility study phase

5.4.1 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.

5.4.2 Technical evaluation

The potential impacts on products, production processes and safety from 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.

5.4.3 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.

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

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 to existing conditions will need to be calculated. It may be that operating costs reduce as a result of the change, in which case, these should be accounted for in the evaluation as an ongoing saving.

5.4.4 Environmental evaluation

The objective of the environmental evaluation is to determine the positive and negative environmental impacts of the 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, for example, an increase in electricity consumption 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, some issues may have a higher priority than others.

Aspects to be considered in the 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?

5.4.5 Select options

The most promising options must be selected in close collaboration with management. A comparative ranking analysis may be used to prioritise opportunities for implementation. The concept of such a method is shown below in Table 5-3. 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 discussion.

All simple, cost-free and low-cost opportunities should of course be implemented as soon as possible.

Table 5-3 Example of a weighted sum method for evaluating alternative options

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 odour 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)

5.5 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.

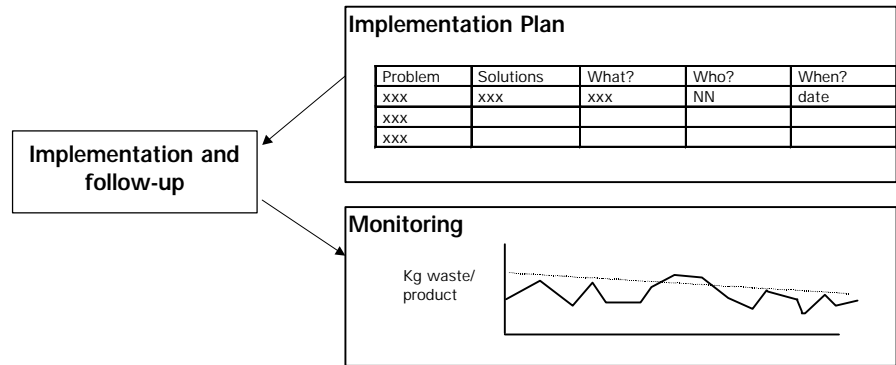


Figure 5—6 Implementation and continuation phase

5.5.1 Prepare an implementation plan

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

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

5.5.2 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 staff. The project could be a failure if not backed up by adequately trained employees. Training needs should have been identified during the technical evaluation.

5.5.3 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 5-4.

5.5.4 Sustain Cleaner Production activities

If Cleaner Production is to take root and progress in an organisation, it is imperative that the project team does not lose momentum after it has implemented a few Cleaner Production options. Sustained Cleaner Production is best achieved when it becomes part of the management culture through a formal company environmental 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.

Regardless of which approach is undertaken, Cleaner Production assessment and environmental management systems are compatible. While Cleaner Production projects have a technical orientation, an environmental management system focuses on setting a management framework, but it needs a technical focus as well.

To assist industry in understanding and implementing environmental management systems, UNEP, together with the International Chamber of Commerce (ICC) and the International Federation of Engineers (FIDIC), has published an *Environmental Management System Training Resource Kit*. This kit is compatible with the ISO 14001 standard.

Like the Cleaner Production assessment, an environmental management system should be assessed and evaluated on an ongoing basis and improvements made as required. While the specific needs and circumstances of individual companies and countries will influence the nature of the system, every environmental management system should be consistent with and complementary to a company's business plan.

Table 5—4 Evaluation checklist

Overall Cleaner Production assessment check	YES	NO
• 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? Which 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		

