4.4 Cleaner Production Assessments

The Cleaner Production Assessment (CPA) is perhaps the core service a centre can offer an enterprise. A good CPA helps the enterprise in many ways. The benefits of a CPA include:

- Identification, characterization and quantification of waste streams and thus environmental and economic assessments of loss of resources (material and energy)
- Identification of easy to implement and low-cost cleaner production options that enterprises can immediately implement; and
- Preparation of investment proposals to financing institutions for undertaking medium to high cost cleaner production measures that may require technology or equipment change.

Additional benefits of a CPA include:

- Building a “cleaner production culture” in the company, which is crucial for long-term sustainability;
- Generating local examples / case studies which could be effectively used in training and awareness-raising programmes;
- Helping in the estimation of the potential of cleaner production in the concerned sector and thus in the formation of the basis for sectoral policy reforms; and
- Helping in identifying the technology and skill development needs of the company and sector.

In fact, conducting the CPA is an excellent method of building competence of the staff at the centre, as well as the staff in the participating company.

A CPA should be conducted in a systematic form and not on an ad-hoc basis. A structured approach is necessary to get the best results. Such an approach ensures that the outcomes of CPA are consistent with those identified in the organization’s broader planning process.
4.4.1 The Generic CPA Process

A generic CPA process consists of the following steps:

- Planning and organization;
- Pre-assessment;
- Assessment;
- Feasibility analysis;
- Implementation; and
- Monitoring.

**Figure 4.5** shows these steps and the related tasks of a typical CPA process.

In this section, we will learn about the CPA process and understand each milestone with associated tools and examples.

While the explanations are oriented to a typical manufacturing enterprise, the guidance is equally applicable to enterprises engaged in service sectors. We will also discuss some of the variations in the generic CPA process.
Figure 4.5: Steps and Tasks in the Generic CPA Process

4.4.2 Planning and Organization

Experience shows that the following elements are important for the successful start of a CPA:

- Obtain commitment of top management;
- Involve employees;
- Organize a cleaner production team;
- Identify impediments and solutions to the CPA as a process; and
- Decide the focus of the CPA.

Planning can begin once one or a few of the staff members of an enterprise become interested in cleaner production. Often, this is a result of the awareness-raising and training programmes. However, a
CPA can only be initiated after a decision has been made by the management to take action.

**Obtain commitment of top management**

If the enterprise decides to involve the centre, a meeting is normally required between the centre and the top management of the enterprise to formalize the decision. Typically, an MoU should be drawn up between the centre and the enterprise, defining the objectives of the CPA, a work plan that indicates time frame, the sharing of responsibilities and sharing of the outcomes, and the fee.

The management of an enterprise has to set the stage for the CPA, in order to ensure cooperation and participation of the staff members. Other than signing an MoU, the commitment of top management takes the form of:

- Directing the formation of a cleaner production team;
- Making the required resources available; and
- Being responsive to the results of CPA.

**Involve employees**

The success of a CPA also depends on the collaboration of the staff. It is important to remember that successful CPAs are not carried out by persons external to the enterprise, such as consultants or the staff of the centre, but by the staff of the enterprise itself, supported if and where necessary by external persons. The staff includes not only the senior management but also the staff on the shop-floor, involved in everyday operations and maintenance. The staff on the shop-floor often has a better understanding of the process and is able to come up with suggestions for improvement. Again, the staff involvement should not be limited to technical or production staff. There can be a considerable role for other departments such as purchasing, marketing, accounts and administration. These staff members provide useful data, especially on “inputs” and “outputs”; assist in the assessment of the economic and financial feasibility of cleaner production options; provide information on alternative raw materials; or, provide market feedback when redesign of products is envisaged.
Organize a cleaner production team

CPAs are best performed by teams, so the formation of one or more teams is an important part of the planning of a CPA. The teams should consist of staff of the enterprise, supported and assisted where necessary by the staff of the centre or by local consultants. Efforts should be made to gel the members of the team by holding frequent meetings. Getting the right mix of team members is crucial, otherwise it is possible that the team may face hindrances from within as well as outside (e.g. from the staff and the workers of the enterprise).

For large organizations, a team could consist of a core team (formed with representatives from different departments) and a few sub-teams for specific tasks. For small and medium scale units, on the other hand, the team could just have the owner or proprietor and a supervisor or manager who looks after the day-to-day operations. This team should initiate, co-ordinate and supervise the CPA activity. In order to be effective, the team should have, on a collective basis, enough knowledge to analyze and review the present production practices. They should have the creativity to explore, develop and evaluate modifications in the production practices. Finally, they must have the competence to implement the economically feasible interventions.

Identify impediments and solutions to the CPA as a process

In order to develop workable solutions, the cleaner production team should identify impediments in the CPA process for a particular enterprise. For instance, there could be impediments in obtaining information from some of the departments. The team should highlight such difficulties right away so that adequate directives can be issued by the management to resolve the issue before the start of the CPA itself. Other impediments could include lack of awareness and / or skills amongst the workers and staff of the enterprise on cleaner production. Solutions to such impediments would typically include performing in-plant awareness-raising sessions, conducting associated training activities, providing and explaining relevant case studies and so on.

Decide the focus of the CPA

Deciding the focus of the CPA involves making decisions concerning:
• The scope; i.e. whether to include the entire plant or limit the CPA to certain units / departments; and

• The emphasis in terms of materials; e.g. water, energy or chemicals.

In the case of a textile industry, for instance, the garmenting department is often excluded, as it does not lead to major consumption of resources or generation of wastes or emissions. In the case of a cement industry, water is not given much emphasis in the CPA as against focus on energy and materials.

4.4.3 Pre-assessment

The first step the cleaner production team will execute is a pre-assessment. This consists of four important tasks:

• Compiling and preparing the basic information;

• Conducting a walkthrough;

• Preparing an eco-map;

• Carrying out preliminary material and energy balances.

Compile and prepare basic information

In this step, the cleaner production team generates two important outputs:

1. A Process Flow Diagram (PFD; and

2. An eco-map of the site.

We will learn about how the team can produce these two outputs in this sub-section.

Preparation of Process Flow Diagram

The preparation of a PFD is an important step in the CPA. To construct a PFD, it is best for the cleaner production team to start by listing the important unit operations right from receipt of raw materials to the storage / dispatch of final products. Next, each of the unit operations can be shown in a block diagram indicating detailed steps with relevant
inputs and outputs. By connecting the block diagrams of individual unit operations, a PFD can be constructed. Sometimes, the best way to create and firm up a PFD is to conduct a number of walkthroughs (see next section).

While preparing a PFD the team should keep the following points in mind:

- Use blocks to denote the operations. For each block, write the name of the operation and any special operating conditions that need to be highlighted; e.g. for a dyeing operation, it may be pertinent to indicate 90° C and 1.2 atmospheric pressure.

- Show points of inspection or quality control in the PFD. Indicate what happens if the material quality is not according to standards. You may need to show whether the materials are rejected or whether they are reprocessed with and without certain additions. This can be done by developing separate flow charts of the rejection scenario.

- Show all inputs and outputs at each block, indicating major raw materials, intermediate and final products, water and steam as applicable; wastewater, air and solid waste emissions. If quantitative records are available, then these could be shown either on the PFD in the form of tables or referred to as attachments to the PFD.

- The PFD should use various symbols to add more information about the process. For instance, indicate clearly whether the operations are batch or continuous. Also, solid and dotted lines can be used to show continuous or intermittent release of emissions, respectively. Colour codes may also be used; e.g. green lines to indicate recycled streams and red lines to indicate release of wastes, etc. All these symbols need to be reflected in a key to the PFD. It is also useful to show the time required for each operation as a typical range; e.g. “2 to 4 hours”, to improve understanding of the process.

- Due attention should be paid to capture start up, shut down and maintenance related activities; seasonal product or production related changes etc. This is best done by preparing a flowchart that indicates how a process or unit operation is operated for a special situation.
**Figure 4.6(a)** shows an illustration of a PFD for a wet-textile processing factory.

**Figure 4.6(a): A PFD for a Wet-textile Processing Factory**

**Figure 4.6(b)** provides a flowchart showing decision points for special situations within it; i.e. whether bleaching and scouring is required, whether the material needs to be dyed.
Figure 4.6(b): A Flowchart Indicating a Process Operation in a Wet-textile Processing Unit for Special Situations

Conducting a walkthrough

A walkthrough is the single most effective technique for getting first-hand information about a production operation in a short time. The cleaner production team should not carry out a walkthrough when the operations are closed (e.g. on the weekend, or during low production cycles, or night shifts). The team should begin every walkthrough from the raw materials receiving area and end it at the department concerned.
with the finished product. A walkthrough thus essentially follows the PFD.

The walkthrough should also cover all the support utilities such as boilers, power generators, fuel storage tanks, pump-houses, refrigeration plants, raw water treatment plants, wastewater treatment facilities, etc.

Box 4.3 provides a checklist of recommended questions while conducting the walkthrough. These questions provide leads for discussions and, importantly, to get an insight on cleaner production options.

<table>
<thead>
<tr>
<th>Box 4.3 Checklist of Questions to be Asked During the Walkthrough</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Work floor or shop floor -</strong></td>
</tr>
<tr>
<td>• Is the floor dirty or ponded?</td>
</tr>
<tr>
<td>• Can the workers move about easily? Is there unnecessary piling of raw materials and stocks?</td>
</tr>
<tr>
<td>• Is the layout optimum; i.e. can the workflow be improved to minimize movement of materials and walking time?</td>
</tr>
<tr>
<td><strong>Storage areas -</strong></td>
</tr>
<tr>
<td>• Is the storage system FIFO (i.e. first in first out; raw material is utilized based on the date of procurement, giving preference to old stock) or LIFO (last in first out; fresh raw material is utilized first, while the old stock of raw material remains unutilized)?</td>
</tr>
<tr>
<td>• How are the received raw materials checked for quality?</td>
</tr>
<tr>
<td>• Are there frequent instances of receiving raw materials that do not meet the required specifications? What happens to the rejects?</td>
</tr>
<tr>
<td><strong>Equipment and process -</strong></td>
</tr>
<tr>
<td>• Is the process operated as per the Standard Operating Practice laid down by the equipment/technology provider? What are the reasons if there are any variations?</td>
</tr>
<tr>
<td>• Is the equipment upkeep regularly conducted? What are the operating efficiencies of the equipment? Are machine breakdowns or problems recorded and their causes corrected regularly?</td>
</tr>
</tbody>
</table>
| • Are quality assurance / quality control done for the finished and intermediate products? How frequently? What are the
current results?

Boiler and steam distribution system -
• Are there any leaking joints, glands, valves, safety valves?
• Is the condensate being returned to the maximum extent possible?
• Are the condensate return lines and feed tanks jacketed or lagged?
• Are steam traps of correct types being used for each process?
• What is the fuel used? Is it of a consistent quality and composition?
• What is the source of water? Is the raw water treated before use?
• What is the type of boiler (e.g. single pass / double pass, etc.)? How frequently does the boiler blow down?

Waste and emissions -
• Is the waste properly collected, segregated and transported?
• Is the waste generation continuous? Or in spurts?
• Are any measurements made of waste generated or emissions emitted?
• Are any valuable raw materials or products wasted as part of the emissions? Is it possible to reuse or recycle them if recovered?

Box 4.4 lists the dos and don’ts that may be followed while conducting the walkthrough.

Box 4.4 Dos and Don’ts to be Followed During the Walkthrough

Do not find faults. A walk-through is not for fault finding. It is to understand material and energy flows better, and to generate ideas for efficiency gains, higher profitability and overall environmental improvement. A walk-through is also to “make friends” for future contacts and possible partnerships. Hence, do not be critical, but be constructive and make suggestions.

Do not dominate or take over the conversation. During the walkthrough, give a chance for the responsible staff to speak and explain.
Do not ask questions to show your knowledge about the process or digress by sharing information that you know but is not relevant.

Ask questions only when you must. If you do not understand explanations provided and feel that they are absolutely critical, then make a request to explain again. Do not feel shy to express your inability to understand.

Do not leave the group. It can project a not-so-polite image.

Ensure that you meet the timeline earlier agreed.

Always keep track of the outputs you are expected to produce. Observations should be made to allow for the correct development of the layout and the PFD. Notes should be taken to allow computation of preliminary material balances. It is also important to obtain information on individual operations and key operational sequences.

Box 4.5 presents some of the resources that the team would need to prepare for before conducting a walkthrough.

**Box 4.5 What You Should Equip Yourself with While Conducting the Walkthrough**

- A camera to take photographs (note that if outsiders are involved in the team permission from the management for use of the camera is essential).

- Scrap book A3 size to make quick sketches, especially for layouts, Eco-maps (see the next sub-section) and PFD.

- Color pens or highlighters to mark important points.

- A tape recorder to record your site observations; however, care should be taken that it does not intimidate personnel on the factory floor.
Preparation of an eco-map

Eco-mapping is a very useful tool for a cleaner production team to use, especially for capturing the observations made during the walkthrough. It is a simple and practical tool to represent visually issues of concern as well as note some of the good practices. Using an eco-map, corrective measures can be implemented to improve not only the environmental performance of a company but also the efficiency of its operations.

Eco-maps are often direct indicators of the housekeeping status of the enterprise. Eco-maps can be developed for specific themes as the following:

- Water consumption and wastewater discharge;
- Energy use;
- Solid waste generation;
- Odours, noise and dust; and
- Safety and environmental risks.

To draw up eco-maps it is easiest to use layout maps of the site. The enterprise may already have such layout maps. If so, before using them it is important that the team adds / verifies the various details by actual inspection. Many a time, records like maps are not always updated. If the enterprise does not have layout maps, the team should construct them. As far as possible, the team should ensure that layout maps are drawn to scale, preferably on A3 size sheets, covering the following:

- **Layout map of the entire operations in the organization:** This map should show the internal roads, entry and exits, raw materials storage, waste storage, processing, disposal facilities, utilities such as boilers, stack positions, storm water drains and wastewater outlets.

- **Layout map of key departments:** For enterprises with a number of large departments, layout maps may be drawn for departments of concern indicating the positions of the major

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1 For more information on eco-mapping, visit the web page of the International Network for Environmental Management on Eco-mapping at: [http://www.inem.org/htdocs/ecomapping/ecomapping_cs.html](http://www.inem.org/htdocs/ecomapping/ecomapping_cs.html)
equipment, water piping; steam lines; drains and vents / stacks. If the department has multiple floors then a separate layout map is required for each floor.

Figure 4.7 shows an illustration of a typical plant layout.

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For each eco-map, the team should make sure to include everything related to the particular problem being studied. For instance, an eco-map for water consumption and wastewater discharge must pinpoint the location of overflows, spills or excessive use of water etc. These areas can be further marked using colour codes or distinct symbols to show areas that have to be monitored or areas where problems will have to be dealt with as soon as possible. Figure 4.8 shows a typical eco-map.
The team should use eco-maps in the task of problem identification, where visual overlays of eco-maps for various utilities or resources can identify problems. Also, they can be used during monitoring and review, where the eco-map developed before can be compared with the updated eco-map after cleaner production option implementation so as to examine the change. To ensure that eco-maps continue to serve their purpose, they should be updated once a year or every time the work site is renovated or operations expanded.

**Preparation of a preliminary material and energy balance**

A material and energy (M&E) balance is a basic inventory tool, which allows for the quantitative recording of material and energy inputs and outputs. The basis of the material balance is the PFD. An essential step in the M&E balance is to check that “what goes in must come out somewhere.” All inputs should thus have related outputs.

Material balances are typically carried out to make an inventory of the material flows (raw materials, chemicals, water, energy etc.) entering and leaving a manufacturing / service company. Energy balances are useful to find options to minimize the use of energy or to recover the energy lost in the system.
The first task for the team here is to conduct a preliminary M&E balance at processes or departments that have been identified in the planning stage as the focus.

Preliminary M&E balances are normally prepared using secondary data, supported by the information recorded during the walkthrough. Water and energy bills paid give some idea of their consumption levels. On the output side, production figures or orders serviced over a certain period of time can give an estimate of average production. Obtaining figures on wastes and emissions is generally more difficult. Sometimes, concentration data for water and air pollutants exist, which can be estimated back to mass emissions, while data on mass or volumes of solid waste are sometimes available. Often, approximate calculations will need to be used, based on “typical” values given in the literature.

An energy balance is generally carried out through the following steps:

1. For each type of fuel used (e.g. electricity, gas, diesel, fuel oil, etc.), write down the amount consumed over a given period, along with the per unit cost and the total cost for the period, show which of the fuels is used in each area of operations, and show energy flows between the areas.

2. Estimate the proportion of each fuel used in each area of the operations. To do this, the cleaner production team should prepare a list of the rated energy consumption of the equipment, number of equipments and the type of the fuel used. Once done for each of the areas, the percentage usage of each fuel in each area can be calculated.

Generally, M&E balances at this level are best set by examining three months of data and computing monthly averages. Care should be taken to ensure that all quantification is expressed in the right units (preferably SI units), that they are uniform, and that the associated costs are provided.
4.4.4 Assessment

Preparation of detailed material & energy balance

It is probable that the cleaner production team finds substantial discrepancies in the preliminary M&E balance. This may require rediscussing the assumptions behind the numbers, conducting measurements, and making whatever revisions are necessary to the data used for inputs and outputs. Hence, the next task for the team is to prepare detailed material and energy balances around certain parts of the PFD. Developing a detailed material balance for each operation is neither practical nor relevant. The critical operations are generally chosen based on:

- The focus of the CPA and results of the preliminary M&E balance arrived at in the earlier steps; and

- The types of materials and processes used; i.e. operations are selected where hazardous materials are used or where materials used are expensive or where materials are used in quantities exceeding the benchmarks. Detailed M&E balances are often performed when the processes have long operational sequences.

Before concluding the M&E balance it could be extremely useful to assign costs to the materials lost or the waste streams that have been identified in the balance. Experience has shown that this could be the single most important information in convincing the management of an enterprise, of the value of cleaner production and securing their commitment for the next steps. While assigning a monetary value to the materials or waste streams, the team should consider the following:

- The cost of raw materials / intermediate products / final products lost in the waste streams (e.g., the costs of unexhausted dye in waste dye liquor);
- The cost of energy in waste streams, in terms of the energy consumed to heat or chill them;
- The cost of treatment / handling / disposal of waste streams, including tipping or discharge fees if any;
- The costs incurred, if any, in protecting the workers and maintaining safe working conditions (e.g., shop floor exhaust systems);
The potential liability costs from a possible accidental spill, discharge, or leakage.

These costs should be determined at least for each major waste stream. Specific costs (i.e., costs per unit mass / volume of a waste stream) should also be determined so as to be able to compute the savings by reducing or avoiding waste streams. Obviously, the high-cost waste streams would be the most interesting ones to focus on from an economic point of view.

Thus a detailed M&E balance provides the team clues to identify the cause of waste generation or low productivity. We will provide guidance on how to do cause diagnosis in the next sub-section.

Figure 4.9(a) presents an example of a detailed material balance in a wet-textile processing unit.
Figure 4.9(b) shows a detailed energy balance in the same processing unit.

![Figure 4.9(b): A Detailed Energy Balance in a Wet-textile Processing Unit](image)

**Cause diagnosis through the fishbone diagram**

The cleaner production team now needs to start generating cleaner production options. This will be possible through conducting what is known as a cause diagnosis. As the name suggests, the cause diagnosis exercise involves asking the question “why?”, i.e. “why did such a problem or outcome occur?”. It is essentially an exercise to hypothesize over the root causes of any problem.

The team can more effectively conduct a cause diagnosis by using a tool known as the fishbone diagram. The fishbone diagram is an excellent tool for cause diagnosis in complex situations where a number of factors are likely to be involved. Once such a diagram has been
prepared, the team can effectively use it for the generation of cleaner production options (explained in more detail in the following sub-sections).

The technique used in preparing a fishbone diagram is given below. We will use the textile dyeing process as an example. Let us assume that a winch is used as the dyeing equipment. Refer to Figure 4.10 below.

1. **Identify the principal problem** that is to be diagnosed and write it next to the head of the fish. For instance, one of the common problems in textile dyeing is that the shade of the dyed fabric does not match with the shade specified by the client. This is referred to as "low Right First Time (RFT)". This causes excessive product reject, thus lowering productivity and generating waste (improperly dyed cloth).

2. **Identify the primary causes** of the problem. Primary causes are typically categorized *generically* as Man, Method, Material and Machine. To illustrate further, primary causes to the principal problem of low RFT could be:
   
   (a) “Lack of supervision” (Category = Man);
   
   (b) “Dyeing operation not properly carried out” (Category = Method);
   
   (c) “Poor quality of input materials” (Category = Material); and
   
   (d) “Uneven pulling of fabric in the dye liquor” (Category = Machine).

   These primary causes are to be listed on the “primary fish bones”, as shown in Figure 4.10.

3. Every primary cause is the outcome of one or more secondary causes. Consequently, this step involves identifying the secondary cause(s) attributable to each primary cause. To carry

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2 A winch is an open-top machine with a tub-like structure where the fabric in a “rope” form is pulled through a dye liquor for a number of hours. It is one of the cheapest pieces of equipment used for dyeing, and is therefore extensively used by small and medium sized enterprises.
the illustration further from point (2b) noted above, the dyeing operation may not have been properly carried out due to:

(a) Excessive use of salt in the dyeing operation;

(b) Incorrect procedure followed while dosing the chemicals.

Similarly, for point (2c) noted above, the poor quality of input materials may have been the result of:

(c) Impurities in the dyes used for the dyeing operation;

(d) Auxiliaries for the dyeing operation having exceeded their shelf-life;

(e) Improper storage of fabric used in the dyeing operation; and

(f) Poor quality of water used in the dyeing operation.

These secondary causes are to be listed on the "secondary fish bones", as shown in Figure 4.10.

Note that the technique of identifying the possible primary / secondary causes of any problem involves asking the question "why?"; i.e. "why did such a problem or outcome occur?"

Interestingly, certain causes appear several times in the diagnosis of primary (or perhaps even secondary) causes. Common examples in this case include “poor water quality used in the dyeing operation” and “lack of clear and concise work instructions”. This allows us to identify common causes, which when corrected could resolve several productivity and environment related issues. Options that address correction of the common causes thus become priority options in drawing the implementation plan.

The fishbone diagram is complete at this point. Primary and secondary causes may be colour-coded for the sake of clarity, although this is not a must. Figure 4.10 shows the completed fishbone diagram for the preceding example.
Allotting priorities to the causes identified in the fishbone diagram

The causes identified in the fishbone diagram are only “probable” causes. Thus, the next step is to calculate the extent to which each particular cause contributes to the principal problem. The cleaner production team needs to analyse the extent to which each of these probable causes contributes to the dyeing operation not being carried out satisfactorily. Such an analysis is possible through observations, record keeping, and setting up well-planned controlled experiments designed to isolate a specific secondary cause.

These efforts can assist the team in validating the primary and secondary causes and prioritizing cause elimination.

Tools such as Pareto analysis\(^3\) may be used if a number of primary and secondary causes are to be analysed. The Pareto analysis is used

\(^3\) Sometimes also called the 80/20 rule. This means that 80% of the problems are caused by 20% of the activities, and it is this important 20% that should be concentrated on. Source: Kanji G. and Asher M. (1996) “100 Methods for Total Quality Management.”
to separate the most important causes of a problem from the many trivial ones, and thereby identify the most important problems for the team to concentrate on.

Many cleaner production teams stumble at this juncture, since estimating the relative importance of each probable cause seems a wearisome task. **It cannot be stressed too much that teams should be strongly encouraged to push through with this step completely, since it can avoid significant wastage of time (and money) later on in the CPA.**

**Cleaner production option generation through brainstorming**

Once the points of action and priorities are understood and listed, the cleaner production team should move on to the logical next phase; i.e. option generation.

Option generation is a creative process, and is best performed, as in the case of the cause diagnosis, by the team as well as the enterprise personnel. Including the enterprise personnel in this activity would lead them to have a sense of ownership of the generated options and a deeper sense of understanding as to why a certain option is finally recommended for implementation. The option generation exercise is conducted through **brainstorming**, a commonly used tool for generating ideas. Given a particular item which needs to be resolved, the team and the enterprise personnel have to deliberate on the ways and means of obtaining a solution to it. In this sense, the cause diagnosis described in the earlier section provides a starting framework for the brainstorming exercise.

In a typical brainstorming session, an idea may be proposed by a person, which may be supported and / or extended by other persons. Further discussions yields other new, transformed, opposing and / or supporting ideas, thus **paving the way for the generation of cleaner production options**. The principle question to be asked during the brainstorming session is **"how?"**; i.e. **"how does one solve this particular problem effectively?"**
Cleaner production options could fall under one of the following categories:

**Housekeeping** – Improvements to work practices and methods, proper maintenance of equipment etc., fall under this category. Efficient housekeeping can provide significant benefits in terms of saving resources. These options are typically low cost and provide low to moderate benefits⁴.

A simple example of good housekeeping in a dyeing operation is to clean the floors and machines of dirt, grease, rust, etc. regularly, which will reduce the possibility of accidentally soiling the fabric, and thus minimize the need for extra washing.

**Management and personnel practices** – Management and personnel practices include effective supervision, employee training, enhancing operator skills, and the provision of incentives and bonuses to encourage employees to conscientiously strive to reduce waste and emissions. These options are typically low cost and can provide moderate to high benefits.

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⁴ For more information on housekeeping, refer to the “Good Housekeeping Guide for Small and Medium-sized Enterprises”. Available as: www.getf.org/file/toolmanager/O16F15343.pdf
**Process optimization** – Process optimization involves rationalization of the process sequence, combining or modifying process operations to save on resources and time, and improve process efficiency. For instance, certain washing operations may not be required due to changes in raw materials or product specifications.

**Raw material substitution** – Primary / auxiliary raw materials can be substituted if better options exist in terms of costs, process efficiency, and reduced health and safety related hazards. Such an approach may be necessary if the materials already in use are difficult to source, or become expensive, or come under the purview of new environmental or health and safety regulations. In all cases of material substitution, it is crucial to test the suitability of the new material in terms of environmental and economic benefits, optimum concentration, product quality, productivity, and improved working conditions.

For instance, sodium sulphide and acidified dichromate tend to be used as auxiliary agents in the sulphur black textile dyeing process. However, both these agents are toxic and hazardous to handle. Their usage may leave harmful residues in the finished fabric and generate effluents that are difficult to treat and damage the environment. Both these agents may be safely substituted without a decline in fabric quality, thus eliminating adverse health and environmental impacts. Sodium sulphide may be replaced with glucose or dextrose, whereas acidified dichromate may be substituted with sodium perborate or ammonium persulphate. The substitution of chemical dyes with natural dyes may also be cited as an example of raw material substitution.

**New technology** – Adopting and transferring new technologies can often reduce resource consumption, minimize wastes, as well as increase the throughput or the productivity. These options are often capital intensive, but can lead to potentially high benefits. Modifications in equipment design can be another option, which tends to be slightly less or equally capital intensive as the option for new technology, and can lead to potentially high benefits.

**New product design** – Changing the product design can cause impacts on both the “upstream” as well as “downstream” side of the product.

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5 Sulphur black dyes are generally used to produce a jet black colour in cotton fibres. Sulphur dyes are insoluble and must first be converted to a water soluble form by adding an agent – traditionally sodium sulphide – so that the dyes can be absorbed by the fibre. After dyeing the fabric, the dye is converted back to insoluble form with the addition of another agent, often acidified dichromates.
life-cycle. Product re-design for instance, can reduce the quantity or toxicity of materials in a product, or reduce the use of energy, water and other materials during use, or reduce packaging requirements, or increase the “recyclability” of used components. This can lead to benefits such as reduced consumption of natural resources, increased productivity, and reduced environmental risks. Often, this helps in both establishing as well as widening the market. Product re-design is, however, a major business strategy and may require feasibility studies and market surveys, especially if the supply-chain around the product is already established and is complex.

Recovery of useful byproducts / resources – This cleaner production option entails the recovery of wastes as byproducts / resources, which may have useful applications within the industry itself or outside it. This type of options essentially leads to the reuse / recycle, and thus minimization, of waste as well as to cost savings.

A common example of recovery from a waste stream for many industries is heat recovery through the use of heat exchangers. Such options are typically medium cost and can provide moderate to high benefits.

Onsite recycling and reuse – Onsite recycling and reuse involves the return of a waste material either to the originating process or to another process as a substitute for an input material.

For instance, in the case of a textile dyeing unit, instead of draining off the last cold washes, they can be collected in an underground tank, adjusted for pH\(^6\), and then filtered prior to reuse in subsequent washing operations. These options are typically low to medium cost and can provide moderate to high benefits.

The team should always be made to remember that in general it is better to not generate a waste in the first place, rather than generate it and later recycle or recover / reuse it. Therefore, the team should only consider the latter type of options once all the others that could prevent waste generation have been examined.

In reality, many of the options a team will identify result as a combination of the above categories so as to produce cost-effective and sustainable results. For instance, any option of new technology should be preceded and followed by improvements in management

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\(^6\) “pH” is a term used universally to express the intensity of an acidic or alkaline solution.
and training. In addition, many a time, the option of new technology also requires substitution of raw materials.

It is important to bear in mind that some of the chosen options may require major changes in the processes or equipment or product. Often, these will dramatically reduce waste generation or increase productivity, but they also often imply considerable investments.

Finally, it is equally important to bear in mind that certain chosen options will require thorough laboratory / bench scale / pilot studies to ensure that the product quality does not degrade as a result of their application, and that it is acceptable to the market.

To round off this section, let us now combine our example of the cause diagnosis through the fishbone diagram with the identification of possible options for cleaner production in the form of a table (see Table 4.2).

Table 4.2: Matching the Problems Diagnosed using the Fishbone Diagram with Possible Cleaner Production Options

<table>
<thead>
<tr>
<th>Generic categories as per the Fishbone Diagram</th>
<th>Primary causes</th>
<th>Secondary causes</th>
<th>Possible cleaner production options</th>
<th>Category of cleaner production option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man</td>
<td>Lack of supervision</td>
<td>Absence of clear work instructions</td>
<td>Develop work instructions as Standard Operating Practices (SOPs). Get the SOPs reviewed by external experts. Closely monitor improvements or identify problems faced, if any, in the implementation of the SOPs. Build a record keeping system to monitor SOP related compliance.</td>
<td>Management and personnel practices</td>
</tr>
<tr>
<td>Method</td>
<td>Dyeing operation not properly carried out</td>
<td>Excessive use of salt in dosing</td>
<td>Improve worker instruction and supervision. Redesign the dyeing recipe by changing composition and materials e.g. use of low salt dyes.</td>
<td>Management and personnel practices, Process optimization, Raw material substitution</td>
</tr>
<tr>
<td>Generic categories as per the Fishbone Diagram</td>
<td>Primary causes</td>
<td>Secondary causes</td>
<td>Possible cleaner production options</td>
<td>Category of cleaner production option</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------</td>
<td>------------------</td>
<td>-------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Incorrect procedure followed while dosing chemicals</td>
<td>Improve worker instruction and supervision.</td>
<td>Management and personnel practices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>Input materials are of poor quality</td>
<td>High impurities in dyes</td>
<td>Get the dye purity checked by independent institutions over a number of samples and across commonly used shades, change the supplier if necessary</td>
<td>Raw material substitution</td>
</tr>
<tr>
<td></td>
<td>Shelf-life of auxiliaries exceeded</td>
<td>Improve the inspection at the receiving unit. Check the container labelling, storage and supply systems.</td>
<td>Management and personnel practices</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improper storage of fabric</td>
<td>Ensure proper storage of scoured/bleached materials e.g. on wooden blocks, wrapping to avoid soiling</td>
<td>Management and personnel practices, housekeeping</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor water quality</td>
<td>Analyse the water for constituents such as hardness, total dissolved solids, pH and iron / manganese content, and compare the measured levels with recommended standards. Treat water to ensure that the constituents are within the recommended standards.</td>
<td>Raw material substitution</td>
<td></td>
</tr>
<tr>
<td>Machinery</td>
<td>Poor process control resulting in inconsistent performance</td>
<td>Optimum temperature not maintained in the dye bath liquor</td>
<td>Check the steam inlet position and steam pressure to ensure that heating is optimum. Take readings of temperature of the liquor before and after requisite modifications</td>
<td>Process optimization, New technology</td>
</tr>
</tbody>
</table>
Generic categories as per the Fishbone Diagram

<table>
<thead>
<tr>
<th>Primary causes</th>
<th>Secondary causes</th>
<th>Possible cleaner production options</th>
<th>Category of cleaner production option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor contact between fabric and dye liquor</td>
<td>Explore changing from a winch to a jet dyeing machine that is enclosed, operates under pressure and imparts better contact between fabric and dye liquor.</td>
<td>New equipment</td>
<td></td>
</tr>
</tbody>
</table>

**4.4.5 Feasibility Analysis**

**Preliminary screening of options**

Once the options are identified through brainstorming, it is important to check whether all causes identified are adequately addressed by the options or whether additional options are required to resolve any causes that still remain outstanding.

The cleaner production team then needs to undertake a preliminary, rapid screening of the cleaner production options developed so as to decide on implementation priorities. In such a screening exercise, the options could be categorized into two classes:

*Directly implementable options*: Those simple options that are obvious and can be implemented straightaway. Generally, options related to housekeeping (e.g., plugging leaks and avoiding spills) or simple process optimization (e.g., control of excess air in combustion systems) fall into this category. For these options no further detailed feasibility analysis is required. Furthermore, their immediate implementation gives management real, tangible benefits in a short period, which makes them more comfortable with the cleaner production assessment.

*Options requiring further analysis*: Those options that are technically and/or economically more complex. Most of the options related to management improvement, raw material substitution, and equipment / technology change, would fall into this category. Some of these options could even be put into a sub-category: those that
require much more information collection or are difficult to implement (due to reasons such as very high costs, lack of technology, requiring major changes, etc.). These can be left pending for later consideration.

**Detailed screening of options**

The team can now undertake a detailed screening of the options in the category requiring further analysis in order to determine which of the options are technically feasible, and ascertain both the economic and the environmental benefits of implementing these options. Each of these aspects is described below.

**Technical evaluation**

The technical evaluation should cover the following aspects:

*Materials and energy consumption* – For each option, it is important to establish material and energy balances for conditions before and after implementation to quantify the materials and energy savings that will result.

*Product / byproduct quality* – Assess the product / byproduct quality before and after the implementation of the option.

*Right First Time* – Provide estimates on the possible improvement of the RFT corresponding to before and after option implementation.

It is also important to examine the following aspects from the point of view of implementation.

*Human resources required* – whether the option can be implemented by in-house staff, or whether external expertise or collaboration with partner organization is required.

*Risks in implementing the option* - Some options may not be fully proven and may require laboratory scale experiments or pilot studies to assess the outcomes before a full-scale implementation is carried out. Some options may affect the key production process or product features, so the potential impact on the business if the option does not work as planned is very high.

*Ease of implementation* – The technical ease with which an option can be implemented will depend on such things as the layout...
of the production processes and of the auxiliary services such as steam lines, water lines, inert gas lines, etc., the physical space available, the maintenance requirements, the training requirements, etc. Also, if options require working on key production processes, the timing of the options’ implementation becomes critical. If the option requires major changes in, or interruptions to, production patterns, any loss in production needs to be factored into the economic analysis of the option.

*Time required for implementation* – Time required if equipment or material needs to be procured, installed or commissioned including consideration of shut-down time for affecting the implementation of the option.

*Cross-linkages with other options* – Whether a particular option is linked to implementation of other options and / or whether the option is best implemented stand-alone or in consideration with other options.

**Environmental evaluation**

The environmental evaluation of an option should ideally take into account its impacts on the entire lifecycle of a product or a service, wherever practically possible. In practical situations, however, the evaluation is often restricted to on-site and off-site (neighbourhood) environmental improvements.

The environmental evaluation should include estimation of following benefits that each option can bring about:

- Likely reduction in the quantity of waste/emission released (expressed on a mass basis);

- Likely reduction in the release of hazardous, toxic, or non-biodegradable wastes/emissions (expressed on a mass basis);

- Likely reduction in the consumption of renewable natural resources (expressed on a mass basis);

- Likely reduction in consumption of non-renewable natural resources, e.g. fossil fuels consumed (expressed on a mass basis);

- Likely reduction in noise levels;
• Likely reduction in odour nuisance (due to elimination of an odorous compound);

• Likely reduction in the on-site risk levels (from the point of process safety);

• Likely reduction in the release of globally important pollutants, viz. ozone depleting substances, greenhouse gas emissions.

Economic evaluation

The team must now evaluate the economic benefits of all the reductions in waste generation and resource consumption that each option can bring about. It must estimate the immediately obvious savings in the purchase costs of materials and fuels, the treatment and disposal costs avoided as well as the material and waste stream costs (identified during the M&E balance earlier). However, it must also estimate less obvious financial benefits such reduced sick days for workers or generally higher worker productivity, lower personnel costs from reducing the burden of special management and reporting of hazardous materials, wastes and pollution, reduced worker and environmental liability, potential profits from sale of waste as by-product, from carbon dioxide credits, etc. Experience has shown that such an expanded financial assessment often helps in considerably improving the economic feasibility of an option.

The team must also estimate the economic costs of each option, in the form of investments in new technology or equipment, but also in terms of training and other costs ancillary to the implementation of the option.

These benefits and costs are then analyzed and computed using various evaluation criteria [e.g. pay back period, Net Present Value (NPV), Internal Rate of Return (IRR), etc.].

A simple payback period is evaluated based on a comparison of the annual savings and the initial investment. It simply indicates the time period to return the initial investment.

It is calculated as,

\[
\text{Payback Period in years} = \frac{\text{Capital Investment}}{\text{Annual Savings}}
\]
The payback period should be generally considered only as a ballpark assessment as it ignores depreciation of the investment made and the time value of money. Usually, investment decisions can only be made on the basis of payback period alone if the investment required is low and / or the returns are high so that the payback period is less than two years.

If these conditions are not met, a better approach is to use the concepts of NPV or IRR. These concepts consider the time value of cash inflows and outflows during the useful life of the investment made. This kind of economic evaluation requires information on:

- The capital costs associated with any investments required;
- Net revenue, which is computed as a difference between total revenue (that could be higher than the base case) and the operating costs (that are typically lower in the changed scenario); and
- Rates of interest and depreciation to enable computation of the Present Value.

The following are the equations that can be used for computation of NPV:

\[
NPV = -(CF_0) + \sum_{i=0}^{n} \frac{Net\ Cashflow_i}{(1 + r)^i}
\]

\(CF_0 = \) Cash outflow in the first year (capital investment)
\(r = \) opportunity cost of capital (i.e. for a rate of 10% ‘r’ would be 0.1)
\(n = \) useful life of the investment in years

For an investment to be financially viable NPV must be greater than zero.

Another indicator commonly used along with NPV is the Profitability Index (PI). PI is computed as the ratio of the present value of the total cash inflows to the present value of the total cash outflows. For an investment to be financially viable, PI must be greater than 1.

IRR is essentially that rate of return on an investment that ensures that during the investment’s lifetime the net cash inflows (i.e. inflows – outflows) are equal to zero, i.e., IRR is the value of r that gives zero as the value of NPV:
$NPV = -(CF_0) + \sum_{i=0}^{i=n} \frac{Net\;Cashflow_i}{(1 + r)^i} = 0$

This problem is solved by assuming $r$ and then following an interpolation procedure. The IRR is then compared with the rate of interest of the borrowings that may be needed from the market. Typically, if the IRR is lower than the market borrowing rate, then the investment is not considered to be financially viable.

It is useful to carry out a sensitivity analysis to understand the “ruggedness” of an option. This can be done by varying the expected efficiencies or yields, prices that the by-products may fetch in the market, or the capital costs of new equipment, and see how much of an effect these have on the outcome. This can help in building both optimistic and pessimistic scenarios to test how sensitive the IRR or NPV are to the data assumed in the economic analysis.

Consider an example of changing six existing winch machines to three jet dyeing machines at a textile dyeing unit. Jet dyeing machines are superior to winch machines in productivity, resource consumption, dyeing quality and versatility. Effectively, three jet machines will result in the same level of production as will six winch machines.

**Figure 4.12** presents a cash flow diagram showing various inflows and outflows. The results of payback, NPV and IRR are also given.
Savings of US$ 54,600 each year are due to the improved right first time with jet dyeing machines. Improved right first time means less processing and hence less water, energy and dye consumption. Apart from reducing purchase costs, these reductions also decrease costs for wastewater treatment. The amount of US$ 23,520 corresponds to increased operation and maintenance cost of the jet dyeing machines over each year and the annual depreciation of the equipment in its life period. Depreciation is calculated based on linear rate and assuming zero salvage value of the equipment at the end of its life period. The capital costs at the 0th year indicate the costs incurred for purchasing the new jet machines (including the installation costs).

The calculations for determining NPV for this example are shown below. An interest rate of 10% has been assumed.
The IRR can be computed through an interpolation process such that NPV is equal to zero.

Based on the equation below:

\[
NPV = -(CF_0) + \sum_{i=0}^{n} \frac{Net\ Cashflow_i}{(1 + r)^i} = 0
\]

NPV = US$ 80,934 for r = 10%
NPV = US$ 45,944 for r = 15%
NPV = US$ 20,262 for r = 20%
NPV = US$ 929 for r = 25%
NPV = US$ 13,954 for r = 30%

Since the NPV has started increasing, the IRR must be between 25 to 30%. Taking mid-points as the next trials

NPV = US$ 5,475 for r = 27%
NPV = US$ 2,363 for r = 26%

And so on to find r = 25.5% as IRR for NPV to be close to zero.

The cash flows can be more complex than the one showed above. The costs of machine operation and maintenance could increase over time. Similarly, the savings could be more as the unit rates for water, energy and dyes are expected to increase. In such cases, software tools such as P2Finance can be used that allow for computation of NPV and IRR for non-uniform cash inflows and outflows.\footnote{The software package for P2Finance may be downloaded from http://www.tellus.org/general/software.html}

It is important to note that NPV and IRR should always be studied together for a realistic analysis. For instance, it is possible that the

\[
NPV = US$9141
\]

\[
NPV = US$80,934 \text{ for } r = 10\%
\]

\[
NPV = US$45,944 \text{ for } r = 15\%
\]

\[
NPV = US$20,262 \text{ for } r = 20\%
\]

\[
NPV = US$929 \text{ for } r = 25\%
\]

\[
NPV = US$13,954 \text{ for } r = 30\%
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\text{NPV} = US$5,475 \text{ for } r = 27\%
\]

\[
\text{NPV} = US$2,363 \text{ for } r = 26\%
\]

\[
\text{And so on to find } r = 25.5\% \text{ as IRR for NPV to be close to zero.}
\]

\[
\text{The cash flows can be more complex than the one showed above. The costs of machine operation and maintenance could increase over time. Similarly, the savings could be more as the unit rates for water, energy and dyes are expected to increase. In such cases, software tools such as P2Finance can be used that allow for computation of NPV and IRR for non-uniform cash inflows and outflows.}\footnote{The software package for P2Finance may be downloaded from http://www.tellus.org/general/software.html}
\]

\[
\text{It is important to note that NPV and IRR should always be studied together for a realistic analysis. For instance, it is possible that the}
\]

\[
\text{\textbf{PART 4}}
\]
absolute returns from an investment are more than those of another investment even when the IRR value for the former is lower than the latter. Thus a study of the IRR alone could be misleading while deciding the investment options.

**4.4.6 Implementation of Cleaner Production Options**

The three evaluations help to eliminate options that are not viable. The remaining options may be considered in the preparation of a cleaner production implementation plan.

**Prioritization of cleaner production options**

In most cases, after conducting the feasibility analysis, it will emerge that different options have differing levels of technical feasibility, economic viability, and environmental performance. Since it is not desirable to implement all the options at the same time it will be necessary for the team to prioritize the cleaner production options. To assist the process of prioritization, a common evaluation framework will be necessary. A weighted-sum method could be considered for this purpose.

In this method, the team will assign weights to each of the three aspects of the feasibility analysis (technical feasibility, economical viability, environmental performance). These weights could be decided through a brainstorming session and involving the top management. The weights will vary from enterprise to enterprise, depending on their technical competence, financial conditions, environmental sensitivity etc. For example, a financially healthy small-scale enterprise facing considerable environmental pressures may decide to give the highest weightage to environmental performance (say, 50%), less to technical feasibility (say, 30%) and least to financial viability (the remaining 20%). This indicates that the enterprise is most keen to reduce pollution load but does not have high levels of capability to undertake technically involved options.

Once weights are assigned, simple indicators such as “scores” can be developed to assess the relative performance of each option. For example, economic viability could be assessed based on the payback period / NPV / IRR. Environmental performance could be assessed based on percent pollutant load reduction. Technical feasibility could be assessed based on technical complexity, requirements for new equipment / technology, requirement of additional technical skills, etc. Each option is then evaluated on a
subjective basis and scores assigned to each of the three aspects. Scores could have a range such as 0 to 10 where lower scores will imply poor attainment of the performance etc. For example, two options may have IRR of 15% and 33% respectively and hence may be assigned scores of 8 and 5 on the aspect of economic viability.

The weighted sum of the scores will give an index for each option, on the basis of which priorities may be assigned. It should be noted that the intention is not to prioritize each option individually but to group them into categories such as “top priority”, “medium priority”, and “low priority”. This exercise would then be the basis for preparing the implementation plan.

Table 4.3 below presents an illustration of such analysis for prioritizing the cleaner production options.

<table>
<thead>
<tr>
<th>Weights and cleaner production options</th>
<th>Technical Feasibility</th>
<th>Economic viability</th>
<th>Environmental performance</th>
<th>Total weighted index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weights (%) 30</td>
<td>45</td>
<td>25</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Scores for Option One</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>6.25</td>
</tr>
<tr>
<td>Scores for Option Two</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>7.65</td>
</tr>
<tr>
<td>Scores for Option Three</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>4.70</td>
</tr>
<tr>
<td>Scores for Option Four</td>
<td>5</td>
<td>8</td>
<td>3</td>
<td>5.85</td>
</tr>
<tr>
<td>Scores for Option Five</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>8.50</td>
</tr>
</tbody>
</table>

Based on above, Option Five may be considered as high priority, followed by Options One and Two as medium priority, followed by
Options Three and Four. Such a method of prioritization helps in the development of an implementation plan.

**Preparing a cleaner production implementation plan**

An implementation plan consists of the organization of the projects required to implement the options, the mobilization of the necessary funds and human resources, and logistics. Training, monitoring and establishment of a management system such as EMS are also often important components of an implementation plan.

The implementation plan should clearly define the timing, tasks and responsibilities. This involves:

- Prioritizing implementation of options depending on available resources;
- Preparing the required technical specifications, site preparation, preparing bidding documentation, short-listing submissions, etc.; and
- Allocating responsibilities and setting up monitoring/review schedules.

The cleaner production team should give first priority to implementing options that are low in cost, easy to implement and/or are a prerequisite for the implementation of other options. This should be followed by options that require more investment, laboratory or pilot trials, or interruption in production schedules.

Many a time, options are implemented during or immediately after the CPAs at enterprises. The very conduct of a CPA in this form becomes a demonstration for others to follow.

**Sustaining cleaner production assessment**

The application of CPA and implementation of cleaner production options will often require changes in the organization and management system of the enterprise.

The key areas of changes are: integration of new technical knowledge; understanding new operating practices, laying down revised purchasing procedures, installing and operating new equipment, or changing the packaging and marketing of the products/by-products. These changes
will include modified preventive maintenance schedules, waste segregation and recycling practices, etc.

It is important, therefore, to ensure that the CPA is implemented as an on-going activity, by integrating the concept of cleaner production into the enterprise’s management system.
4.5 Demonstration Projects

4.5.1 Introduction

Experience has indicated that the best way to persuade enterprises and institutions to adopt and implement cleaner production is by showing them the results from practical demonstrations. A common barrier to cleaner production is the lack of local examples demonstrating that cleaner production can be applied in the local context to any industrial sector and that waste can be turned into profit. Local entrepreneurs are usually not aware of the scope and potential of cleaner production. A key activity of CPCs, particularly in the beginning, is in-plant demonstration projects, which assist volunteer local companies undertake a CPA and to implement the results, and publicize the results of the CPA to as many other companies as possible.

Generally speaking, a demonstration project is the operation of some hardware (typically a technology, but also materials) or the use of software (for instance, a methodology) that is innovative. Sometimes a demonstration may be warranted because the hardware or software was developed or proven elsewhere but has not been yet adapted to the local situation. Sometimes a demonstration may be needed because not enough technical and financial information is available on implementing the hardware or software. Finally, demonstration may involve a hardware or software that has an element of risk of the unknown that dissuades stakeholders from its application. A demonstration in this case is essentially a confidence building measure.

Many a time, demonstration projects are considered as means to prove a new technology; e.g. an efficient process or equipment. In the UNEP / UNIDO NCPC Programme, demonstration projects are not intended for this purpose. Demonstration projects are basically to showcase a methodology; viz. CPA.

4.5.2 An Overview of Cleaner Production Demonstration Projects

In the early stages, i.e. 1990-1995, demonstration projects were basically catalyzed through several donor-assisted programmes on cleaner production. These projects were more or less technology-equipment driven and were launched to facilitate the dissemination of results to
convince industries of the economic and environmental benefits of cleaner production. The manufacturing sectors where most of the demonstrations were carried out were textile industries, pulp and paper industries, metal finishing works and tanneries.

One of the early demonstration projects was PRISMA. This project was launched in 1988. It had two principal objectives:

- To show the Dutch industry that the prevention of waste and emissions is possible in the short term and that it offers benefits to both companies and the environment.
- To formulate recommendations for an effective pollution prevention policy.

In many ways, PRISMA created the framework for all cleaner production demonstration projects that followed.

Some other trend-setting demonstration projects have been DESIRE in India (implemented by National Productivity Council, New Delhi, with UNIDO), ProduksiH in Indonesia (implemented by the Indonesia Environmental Impact Management Agency, or BAPEDAL, with the support of Gesellschaft für Technische Zusammenarbeit GmbH or GTZ, Germany), and SEAM in Egypt (implemented by the Egyptian Environmental Affairs Agency or EEAA with the support of Department for International Development, or DFID, UK).

Many of the early demonstration projects on cleaner production were fully funded through grants, principally from the international donor agencies cited above, so that the participating enterprises were not required to make a financial commitment. However, the current trend is to require a formal assurance from enterprises that agree to participate (in the form an MOU or otherwise) to commit human resources and sometimes a small, nearly token, amount of money, to ensure meaningful participation in the demonstration and ownership of the results, as well as continuation of cleaner production activities after the demonstration is over.

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8 The acronym “PRISMA” stands for “Project Industriele Successen Met Afvalpreventie”.
9 The acronym “DESIRE” stands for “Diverse, Environment, Simple, Innovative, Rational, and Economical”.
10 The acronym “SEAM” stands for “Support for Environmental Assessment and Management”.

"Do not make the mistake of imposing yourself as a fault-finding specialist. It is not enough to identify cleaner production opportunities; company personnel have to implement them for the demonstration project to be successful. Try to get the words from their mouth.

Make them own the cleaner production options as if they have developed them. Then you have a fair chance of getting it implemented.”

- India NCPC
PART 4

The Asian Productivity Organization, or APO, based in Tokyo, has supported a number of Green Productivity Demonstration Projects (GPDP), which are very similar to cleaner production demonstration projects, in various Asian countries. The United States Agency for International Development (USAID) under the Environmental Pollution Prevention Project (EP3), which concluded in 1998, the World Environment Centre (WEC) and the World Cleaner Production Society (WCPS), have all co-financed and facilitated a large number of demonstration projects in various regions.

The results of all these demonstrations generally have been positive, and case studies / fact sheets have been prepared for distribution or have been uploaded on web sites for wider dissemination. Videos that show interviews with the industry personnel and the facilitators have also been prepared in several cases.

Most of the cleaner production demonstration projects have primarily focused on preventing or reducing waste or pollution, or increasing efficiency. Issues such as market access, supply chain requirements, occupational safety and health, and community participation have often not been adequately covered, if at all. An exception is the SEAM Programme in Egypt, which has supported demonstration projects focusing on protecting / widening Egyptian exports to the European Union and US markets by securing ecolabels. The demonstrations here have shown that the companies not only secured ecolabels and widened their export market, but also increased their productivity and cut down costs of input resources.

In general, cleaner production demonstration projects have taken place in the manufacturing sector. Promoting demonstrations in the service sectors and communities is a recent phenomenon. APO has, for instance, initiated Green Productivity Demonstration Projects in the tourism sector and has set up demonstrations in communities in Vietnam. The Cleaner Production and Industrial Efficiency (CPIE) project in Thailand, supported by the Asian Development Bank (ADB), is demonstrating the utility of the 5S concept for implementing cleaner production in a small textile printing company.

11 Based on Japanese words that begin with ‘S’ (Seiri = organization, Seiton = neatness, Seiso = cleaning, Seiketsu = standardization, and Shitsuke = discipline), the 5S Philosophy focuses on effective work place organization and standardized work procedures. 5S can simplify your work environment, reduces waste and non-productive activity while improving quality, efficiency and safety. Refer to: Osada T. (1991) “The 5S’s – Five Keys to a Total Quality Environment.”
Cleaner production demonstration projects have always been a strong element of the UNIDO/UNEP NCPC Programme. As stated earlier, in this programme, emphasis is given to demonstrating a methodology rather than technology, new materials, know-how, or equipment. This concept has been now adopted by other programmes as well. For instance, in the Cleaner Production and Industrial Efficiency (CPIE) project supported by Asian Development Bank, the demonstration project at a textile printing factory consisted of implementing the 5S methodology, and showing the environmental and economic benefits of doing this. In a study conducted in 1994/95, the Danish International Cooperation Agency (DANIDA)\textsuperscript{12} has emphasized that the effectiveness of demonstration projects is limited if the concept is confined to a narrow technical approach.

**4.5.3 Benefits of Demonstration Projects**

The primary objective of the demonstration projects is to show, at the local level, the potential, relevance and applicability of cleaner production approaches, with a view to encouraging their wider adoption across the target stakeholders.

In this perspective, the demonstration projects have several side-benefits for the centres:

- They provide the Directors with an opportunity to build locally relevant case studies for preparing content for awareness-raising materials. In this sense, demonstration projects are an awareness-raising mechanism.

- Demonstration projects help CPCs to widen their market. Enterprises that participate in the demonstration realize the “cleaner production advantage” and help in spreading the message across the sector or in the geographical cluster.

- They provide an opportunity for the centre staff to understand and be trained in CPA and implementation methods, especially in the early years of operation.

- They help in establishing partnerships and networks with local consultants. This enables the centre to build up a group of experts

\textsuperscript{12} “Analysis of Donor programmes for promotion of Environmental Management, Pilot Programme for Promotion of Environment Management in the Private Sector of Developing Countries”, GTZ, April 1998.
who can undertake further cleaner production assessments and demonstrations.

- They help in building capacities at the participating enterprises to sustain cleaner production.
- Finally, they help in building the centre’s “consultant qualifications” that will help in marketing the centre’s services.

### 4.5.4 Preparatory Activities

**Identification of the stakeholders in the demonstration project**

Other than the enterprises themselves, which will be the “guinea pigs” for a demonstration project, the stakeholders in a demonstration project typically include:

- Enterprise associations;
- Relevant research / technology institutions;
- Financing institutions; and
- The Cleaner Production Centre.

Generally, regulatory agencies are not involved as stakeholders since their involvement can create barriers.

**Selecting the enterprises**

Selection of enterprises is often the key to a successful demonstration project. The enterprises are generally identified by examining the priority sectors of economic activities, size and geographical distribution of the enterprise and prevailing environmental problems.

The PROPEL\textsuperscript{13} Programme [in Colombia, supported by the International Network for Environmental Management (INEM), Germany] and SEAM / Egypt (supported by DFID in partnership with EEAA) completed sectoral reviews at the outset to identify priority sectors, and then identified geographic locations and facilities of

\textsuperscript{13} The acronym “PROPEL” stands for “Promoción de la Pequeña Empresa Ecoh
diciente Latinoamericana”.

importance to which to propose demonstration projects. USAID’s EP3 programme in Indonesia focused on areas that were relevant to many small and medium scale enterprises of a particular sector of focus.

In these cases, sectors for demonstrations were chosen on the grounds of economic and environmental importance, current technology and financial absorption capabilities, as well as the magnitude of populations dependent on the sector for employment.

It is extremely important for Directors to choose very carefully the enterprises that will participate in a demonstration project. If participants do not actively participate then the value of the whole demonstration project is jeopardized. With experience, existing Centres have evolved various strategies to ensure that they choose participants well.

- It is important to secure commitment and willingness for the demonstration project from the highest levels of the enterprise, for instance, the owner in a small enterprise, the site manager, and so on.

- It is good to choose wherever possible enterprises whose owner/top management is dynamic, forward-looking, risk-taking, and seen perhaps by the local competitors as being a “leader”. Such persons will be more willing to take on the “unknown” that a demonstration project consists of and carry through the commitment.

For example, the criteria which the India NCPC uses are:

*Significant multiplier effect*: The basic purpose of a demonstration project is to show and convince other industries of the potential and feasibility of cleaner production. It is therefore essential that the sector selected is large enough to have a significant multiplier effect.

The multiplier effect is governed by two factors:

- Number of clusters of similar units; and

- Total number of units in the selected sector.

A sector with a large number of units in clusters would be preferable to one with a few dispersed units.
High possibility of replication by other units: For an effective multiplier effect is important that demonstrated cleaner production measures be replicated by other units throughout the sector. Two factors should thus be considered when selecting an industry sector:

- Uniformity of production processes and products; and
- Availability of technical manpower within the units.

Substantial cleaner production potential: Not all industry sectors have the same potential for cleaner production. In the early stages, when success needs to be demonstrated to prove the usefulness of the centre, industry sectors with the greatest cleaner production potential should be selected over those where it may be more difficult to obtain clear results.

Significant pollution intensity: The advantages of cleaner production may at first be more persuasive in industry sectors that are pollution intensive rather than those in which pollution is much less, although the cleaner production potential will also need to be considered. Pollution intensity could be measured in terms of waste quantity, toxicity, concentration of pollutants in waste streams, etc. Cleaner production in a pollution intensive sector could also lead to a substantial decline in end-of-pipe pollution control requirements, thus making cleaner production a more obvious and attractive preference.

High economic importance: It has been the experience of the India NCPC that industry sectors which are important in the national economic scenario accept newer concepts like cleaner production more readily. The economic importance of the sector has several facets such as impact on imports/exports, overall gross output, relationship with other up-stream or down-stream sectors, etc.

Good potential cooperation from industries: Industry cooperation in cleaner production assessment and implementation is vital for a successful demonstration project. It has been observed that the cooperation from industries varies widely from sector to sector as well as from place to place.

Stable financial health of the sector: In the experience of the India NCPC, there is no clear correlation between an industry sector’s financial situation and its receptivity to cleaner production. The sectors which have reached a plateau of growth and can foresee a possible decline in future profits unless corrective measures are
taken, have tended to be the most suitable ones for early successes.

*Intense intra-sectoral competition:* Industry sectors characterised by intense competition tend to be the most receptive to cleaner production. However, when cleaner production demonstrations have proved successful, there is less willingness to share the information with other units in the industry.

*Sufficiently organised sectoral structure:* To obtain early success, the Centre should begin with industry sectors which are sufficiently organised to be able to initiate and sustain a cleaner production programme. Industry sectors with informal structures are likely to have greater difficulty in obtaining success for reasons such as lack of trained / technical manpower, over-burdened management, lack of measurement/monitoring facilities, etc.

*High national priorities:* Finally, the selection of sectors should also recognise governmental priorities (e.g. Ministry of Environment, Ministry of Industry, Pollution Control Boards, etc.) as in the long run, demonstration projects will not serve much purpose unless they are also able to further government polices and programmes.

It may be useful to identify enterprises for demonstrations by holding awareness and training programmes. Promotional events could also be held such as seminars with one to one meetings inviting the target stakeholders. These events can be organized in partnership with the relevant industrial associations or even with financing institutions / government authorities that may sponsor the demonstration project.

Once the stakeholders are identified for demonstration, it is wise to formalize the agreement on the part of an enterprise to take part in a demonstration project, by signing a MoU. In the UNEP / UNIDO NCPC Programme, demonstrations are essentially the conduct of CPAs. The demonstrations are performed in groups where CPAs are undertaken at the same time, governed by the agreement. The MoU helps in establishing a clear understanding on individual as well as collective responsibilities.

**Box 4.6** lists some of the dos and don’ts in identification of enterprises.
Box 4.6 Dos and Don'ts in Identifying Enterprises for Demonstration Projects

- Develop criteria for selecting priority sectors and companies for demonstration projects.
- Only really willing and convinced companies should be considered for demonstration projects.
- The contracts with companies should clearly specify the roles and responsibilities of the enterprise as well as those of the centre.

Selecting Other Stakeholders

It is important to involve those institutions, such as industrial associations, that support the sector to which the demonstration enterprises belong. Since the primary purpose of the demonstration projects is to disseminate the results as widely as possible within the relevant sector, these institutions can be an extremely important mechanism for doing this. In addition, staff of these institutions can be given a thorough training in the basic cleaner production methodologies through the demonstration projects, which they can use to continue offering cleaner production services to their members.

Research and technology institutions can be important if and when research needs to be done on possible modifications to equipment, processes, or raw materials. They will have the laboratory facilities and expertise to carry out such research. In addition, if the staff of such institutions is trained in cleaner production concepts they can add this to the services they already offer, thus increasing the value of these services.

Finally, financial institutions can be important stakeholders in demonstration projects if these could result in the identification of cleaner production options that will be require significant investments to be implemented. Furthermore, the involvement of financial institutions in the details of a demonstration project can greatly increase their awareness of the role that environmental requirements can play in the value (or loss thereof) of industrial investments, which can have important feedback effects on their loan policies.
4.5.5 Conducting the Demonstration Project

After the agreements are executed and commitments have been made in the form of an MoU, the implementation of the demonstration project should be commenced. Implementation is a partnership activity and the sole responsibility of the centre. It is strategic that the centre includes training as a part of the CPA cum demonstration activity to build capacity of the enterprises that have volunteered. Including training of company personnel as part of a demonstration project ensures that cleaner production continues after the external experts leave. Demonstration projects are only one component of a broader programme to build awareness and local capacity for cleaner production.

The Vietnam Cleaner Production Centre trains cleaner production trainers with a systematic, in-depth training programme, consisting of seven modules. During the programme, participants go through a complete cleaner production assessment, coached by national and international experts.

Currently, the programme is directly linked to in-plant demonstration projects; therefore the trainees are given a good practical as well as theoretical grounding in cleaner production by the end of the course. A selection of these trained national experts have been serving as cleaner production trainers / coaches in Phase II, by the end of which the centre plans to have conducted about 15 in-plant demonstration projects. Some of those trained will work as independent consultants on cleaner production.

The China National Cleaner Production Centre has conducted in-plant demonstration / training programmes in some 100 enterprises and cleaner production demonstration activities in more than 20 provinces and large cities. At the start of a cleaner production assessment in an enterprise, the centre provides a one-day introductory seminar for managers and owners of the enterprises to disseminate information on experience with cleaner production techniques and technologies. In each of the 100 enterprises where cleaner production assessments have been carried out, a comparison was done of the extent of pollution generated before and after implementation of cleaner production options using the material balance prepared at the plant level. In all its cleaner production assessments, the centre provides technical expertise for the implementation of cleaner production options at company level. The centre has held seminars to share results with industry associations,
When the NCPC in Tunisia did its demonstration projects, it combined training with CPAs in companies, a factor which the centre believes made the “cleaner production demonstration projects run properly”. The centre built mostly upon the existing expertise and technical capacity of the companies, as it did not have much funding for international consultants. This strategy had two advantages – the expertise stayed within the company and it created a “sustainable momentum”; once the programme was completed, the personnel associated with it continued with the cleaner production philosophy.

**Box 4.7** below summarizes dos and don’ts in the conduct of demonstration projects.

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<tr>
<th><strong>Box 4.7 Dos and Don’ts for Conducting Demonstration Projects</strong></th>
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<tr>
<td><strong>The implementation phase should not wait for the whole assessment to be complete.</strong> The implementation of straightforward cleaner production options should take place alongside the assessment so that the enterprise can start seeing the savings.</td>
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<td><strong>Take time to develop good relationships with enterprise personnel</strong> – the number of demonstration projects is less important than their effectiveness.</td>
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<td><strong>Include the enterprise’s financial managers in the demonstration project</strong> so that the enterprise can accurately calculate its economic interest in adopting cleaner production options.</td>
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<tr>
<td>Find ways to motivate enterprises which do not implement even no- or low-cost options, or to recover the costs to the centre of their involvement if they don’t.</td>
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<tr>
<td><strong>Evaluate demonstration projects periodically</strong> for a better understanding of which options did or did not get implemented, and why.</td>
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<tr>
<td>If enterprises don’t implement capital-intensive cleaner production options for lack of finance, develop the expertise to</td>
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convert such cleaner production options into bankable loan proposals and act as intermediary between financial institutions and the enterprises.

The objective of a demonstration project should not just be to identify a number of cleaner production options and present them in the form of a report; it should be a satisfactory completion of the project with the maximum possible level of implementation of cleaner production options identified, and to build enterprise expertise to spread cleaner production in the enterprise and industry sector.

4.5.6 How to Disseminate the Results of the Demonstration Project

This is a key part of demonstration projects, because it is only if this is done well that the project can truly be said to have demonstrated cleaner production and its benefits. Based on the experience gathered by existing centres, Directors can consider various means of dissemination.

At the end of the demonstration project, centres should hold one or more seminars to which they invite as many as possible of the enterprises that belong to the sector or geographic zone that was covered by the demonstration project, as well as other concerned stakeholders, where the results of the demonstration project are presented. The impact is greatest if the enterprises that took part in the demonstration project present their results and discuss their experiences.

In the case of sector-specific demonstration project, centres may team up with a sector association or other sectoral support institution (e.g. a sectoral research association) to organize such a seminar. Such partnering might draw more organizations / institutions to the event.

Centres should also prepare a report that outlines the results of the demonstration project in the form of a guidance manual. The purpose of this manual is to assist other enterprises that have been motivated by the presentation of the demonstration project’s results or in some other way to launch cleaner production assessments and other activities. For the sake of comprehension, it should be produced in all the necessary local languages. Centres can also prepare one-page leaflets on some of the more significant results that came out of the demonstration project, as mailers for inclusion as part of the promotional material of the centre.

“Nothing works better within an industry group than a colleague telling them about things. Demonstration companies should become ambassadors of cleaner production. This they will only do if they get something out of it. So you need to make sure that you are passing on the skills, not taking the expertise out with you. This may take several months of building up relationships, but if you are not able to develop personal relationships with your partners, the project will not be sustainable.”

- India NCPC
If funds are available, then centres can make a video of the demonstration project. This can be expensive, since it requires the use of highly experienced professionals, but it gives a product that can lead to a better and wider communication of the concept, working and the results. As an alternative to creating their own videos, centres could consider partnering with a local television station.

Whatever dissemination mechanisms Directors adopt, they must make sure that the information about the demonstrations is reaching the target stakeholders. Box 4.8 provides guidance on the dissemination of information.

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<tr>
<th>Box 4.8 Dos and Don’ts for Disseminating Results of Demonstration Projects</th>
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<tr>
<td>The objective of information dissemination should be to provide information which is required by the user (\text{(demand-driven)}) rather than providing information simply because it exists (\text{(supply driven)}).</td>
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<tr>
<td>Different stakeholders have different information needs. A centre should do an ‘information needs’ survey to identify and understand actual information needs. Specific information packages should then be developed taking into account the relevance of the information to the user, its presentation in a ‘directly usable’ format and the user’s capability and facility to apply the information.</td>
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<tr>
<td>Maximize use of existing information dissemination channels and networks instead of creating new ones. Piggyback on existing nodal points (industry associations, government agencies, etc.) as a resource-effective means of providing information.</td>
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<td>Information dissemination is continuously evolving; the information needs of yesterday may be quite different from the needs of today and tomorrow. Develop a feedback system to continuously assess and meet user needs.</td>
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<tr>
<td>Feedback from local cleaner production users should be made accessible to regional and global networks to enable others to integrate grass roots needs into development projects.</td>
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4.5.7 The Role of the Centre in Selecting, Planning and Conducting Demonstration Projects

The centre should be involved in the demonstration project as a mentor, a facilitator, as well as in the guise of a professional manager. The points below summarize the role of the centre in this perspective.

1. Select the sector or geographical area in which a demonstration project will take place.

2. Publicize to the members of the chosen sectors or in the chosen geographical areas the fact that a demonstration project will be held for them.

3. Select the enterprises (or other organizations and institutions) that will take part in the demonstration project.

4. Come to a formal agreement with the selected enterprises and organizations/ institutions about the form and content of their participation in the demonstration project.

5. Set the schedule for the demonstration project.

6. Provide methodological inputs and technical support. Include training as a part of the demonstration activity.

7. Select (and if necessary contract with) the national consultants who will mentor the enterprises (or organizations / institutions) during the demonstration project and possibly the person who will be the team leader for the whole project.

8. Monitor the progress of the demonstration project, and if necessary take corrective action if there is slippage in the schedule or other problems.

9. Ensure that the necessary photographs, videos, etc. are taken during the work to track progress and to use as promotional material later on.

10. Prepare the overall project report.

11. Hold the necessary awareness-raising and dissemination campaigns at the end of the project.