Cleaner production is the continuous application of an integrated preventive environmental strategy to industrial process, products and services so as to increase efficiency and reduce risks to humans and the environment. The objective of cleaner production manual for textile industries is to provide step by step guidance on how to conduct cleaner production assessment and implementation. The manual explains all steps which managers for small, medium and large textile industries can use to conduct cleaner production assessment and finally implement it.

The central element in cleaner production assessment is the analysis of material and energy flow entering the process in order to identify opportunities for cleaner production and solve problems related to waste and emissions at their source.

The manual provides the essential information and worksheets used to conduct cleaner production assessment. It comprises of mainly five phases and several steps for each phase. The first phase is called planning and organization. The objective of this phase is to convince the management and employees in the industry of the need for cleaner production.

The steps for this phase are to get management commitment and involvement cleaner, form a project team, establish cleaner production goals, identify barriers and find solutions. The second phase is called pre-assessment, it involves development of process flow chart which describes the entire facility, and it shows all steps through which the raw materials pass to form a product. Other steps are evaluation of inputs and outputs, setting of cleaner production focus and evaluation of occupational health and safety. The third phase is called the assessment phase. The stages involved are to derive the material balance which helps in identification and quantification of unknown emissions and losses, conducting of a cause assessment to show the sources and causes of waste emissions and energy loss, generation and screening of cleaner production options. Feasibility study is the fourth phase. The steps involved are preliminary evaluation, technical evaluation, economic evaluation, environmental evaluation and selection of options for implementation. The fifth phase is called the implementation phase, which includes steps for preparation of cleaner production plan, implementation of cleaner production options, sustain cleaner production activities and evaluation of implemented options.

Sustainability of cleaner production activities within the industry could be possible if the industry should continuously find ways to improve its environmental performance and that cleaner production should remain to be the priority for the management and employees of the industry.
Acknowledgement

This Cleaner Production Implementation Manual for Textile industries in Tanzania is the result of the collaboration of the environmental activists towards safe and healthy environment on behalf of the Government of Tanzania. Envirocare as a secretariat to the activists coordinated the development of the manual under the supervision of its Executive Director, Ms. Loyce Lema. The activists’ members during their meeting critically reviewed drafts of material for this manual.

Envirocare acknowledges the increasing interest of practicing Cleaner Production in Textile industries and attempts to achieve the integration of environmental, social and economic impacts.

A draft of this manual benefited greatly from peer review of panel of textile specialists who devoted considerable time and effort to improving the draft. Their advice and encouragement was invaluable in determining the final structure and content. The authors are indebted to the following institutions: National Environmental Management Council (NEMC), Ministry of Industries, Trade and Market, Tanzania Bureau of Standards (TBS), Government Chemist Laboratory Agency, Ardhi University and Occupational Safety and Health Authority (OSHA).

Thankful acknowledgement is also made to Mrs. Salu R. Mzava who dedicated most of her time in editing this manual. She even advised on the contents and layout of the manual.

This Cleaner Production Manual will be very helpful in many Textile industries to guide them on how to conduct Cleaner Production. It is also dedicated to all Textile industries in Tanzania and all industrial managers, workers, consumers and stakeholder
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Introduction

Cleaner Production (CP) is an essential part of any comprehensive pollution management system at an enterprise or national level. Significant reductions in pollution loads can often be obtained at a little cost and efficient use of resources and reduction in wastage in industrial production are clearly preferable to reliance on end-of-pipe treatment.

Cleaner Production (CP) is promoted because it minimizes the use of resources and reduces the wastes discharged to the environment. In many cases the implementation of Cleaner Production (CP) improvement can reduce or even eliminate the need for end-of-pipe investments and therefore can have both environmental and economic benefits. As a rough guide, 20-30% reductions in pollution can often be achieved with no capital investment required and a further 20% or more reduction can be obtained with investments which have a payback time of only months.

Cleaner production is a general term that describes a preventative approach to industrial activity. It is neither a legal nor a scientific definition to be dissected, analyzed or subjected to theoretical disputes. It is a broad term that encompasses what some countries call waste minimization, waste avoidance and pollution prevention.

Cleaner production refers to a mentality of how we produce our goods and services with the minimum environmental impact under present technological and economic limits. Generally, cleaner production is for saving, cost reduction and pollution prevention.

The definition that has been adopted by UNEP is the following: “Cleaner Production is the continuous application of an integrated preventative environmental strategy to processes, products, and services so as to increase efficiency and reduce the risks to humans and the environment”.

The main emphasis is clear. It is important to focus on the manufacturing process and also to take a life-cycle approach to products and services themselves.

For production processes, cleaner production includes the efficient use of raw materials and energy, the elimination of toxic or dangerous materials, and the reduction of emissions and waste at the source. For products, the strategy focuses on reducing impacts along the entire life-cycle of the products and services, from design to use and ultimate disposal. Cleaner production involves applying know-how, improving technologies, and above all, changing attitudes in many places.

Cleaner production is a good business and environmental proposition to achieve a lower level of pollution and environmental risk. More efficient use of materials and process optimization results in less wastes and emissions, which in turn result in lower operating costs. Its focus on occupational health and safety also has positive effects on the worker productivity and decrease in accidents.

Implementation of cleaner at one of the textile industry effected saving of 11,158,836 liters of water equivalent to Tshs 3,012,880/= per month, 55,645.2 kg of steam worth Tshs 797,830/= per month, 10,230 kg of solid waste equivalent to Tshs 10,857,132/= per month and Tshs 338,520/= for recycling light caustic soda per month, giving the total saving of Tshs 15,006,368/= per month.

Cleaner Production is especially important to developing countries and countries in transition, as it provides industries in this countries an opportunity to “leap frog” over older, because more established industries are still saddled with costly pollution control techniques.
Cleaner Production Manual for Textile Industries

The manual describes step by step on how to conduct cleaner production assessment and implementation in textile industries. It explains the steps which can be easily followed by managers in small, medium and large textile industries to implement cleaner production.

Cleaner production assessment is the analysis of the material and energy flows entering and leaving the process in order to identify opportunities for cleaner production and solve the problems related to wastes and emissions at their source.

The manual provides the essential information and worksheets to conduct cleaner production assessment. There are five phases in cleaner production assessment in textile industries and each comprising several steps.

1.0 Phase I-Planning and Organization

The objective of this phase is to convince the management and employees in the industry of the importance and necessity to go for cleaner production. This phase starts after one or few persons in the industry become interested in cleaner production after getting enough awareness through training and exposure in various ways. In this course of the phase, an “outsider” or “promoter” should convince key persons in the industry of the necessity to adopt cleaner production and establish a proper project organization for the smooth execution of the cleaner production assessment.

Check list for the Planning and Organization

This checklist should be used to help organize the planning and organization phase. It has to be used again at the end of this phase to evaluate whether or not all important issues of this phase have been addressed. In this case a positive answer implies that a report of other information is available.

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
<th>NOT RELEVANT</th>
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</thead>
<tbody>
<tr>
<td>1. Is the management aware of cleaner production concept?</td>
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<tr>
<td>2. If YES to question 1, is the management committed to cleaner production?</td>
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<tr>
<td>3. If NO to question 1, why?</td>
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<tr>
<td>4. Does the management understand its own involvement in the cleaner production?</td>
<td></td>
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<tr>
<td>5. Has the industry issued the policy statement showing that it supports cleaner production initiatives?</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>6. Have human and financial resources been allocated for cleaner production assessment?</td>
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</tbody>
</table>
7. Has the industry established a team to undertake cleaner production project?  
8. Have tasks and responsibilities been divided among project team members?  
9. Have you analyzed and reviewed present practices of the industry?  
10. Are the employees informed about the cleaner production assessment and the need of the industry to embark into it?  
11. Have short and long term cleaner production goals been set?  
12. Have you developed a plan and time schedule for cleaner production assessment?  
13. Have you identified barriers to cleaner production in your industry?  
14. Have you been able to overcome these barriers?

**Evaluate industrial procedures**

**Explanation:** During the planning and organization, the team should gain some understanding of how the industry is run, and where opportunities for cleaner production can be identified. This insight can help convince the management of the need for cleaner production and may help to set the cleaner production goals.

YES - means your industry is promoting or could promote cleaner production.  
NO - means your industry does not encourage cleaner production.  
NOT - SURE means you need further evaluation of the respective activity.

<table>
<thead>
<tr>
<th>A. General Questions</th>
<th>YES</th>
<th>NO</th>
<th>NOT RELEVANT</th>
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</thead>
<tbody>
<tr>
<td>1. Are you well informed about the cleaner production concepts?</td>
<td></td>
<td></td>
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<tr>
<td>2. Is there someone in the industry who is responsible for environmental issues?</td>
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<tr>
<td>3. Does your industry comply with environmental regulations?</td>
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<tr>
<td>4. Does the environment have a high priority in your industry?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5. Has your industry invested in environmental measures?</td>
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<td></td>
<td></td>
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<tr>
<td>6. Does your industry have a good reputation in the neighborhood/local community?</td>
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<tr>
<td>7. Does your industry have a long-term strategic business plan (more than 2 years)?</td>
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</table>

<table>
<thead>
<tr>
<th>B. Questions specific to the operations plan:</th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1. Are workers and management work together in developing the programme to promote cleaner production?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Are you recycling every waste you have and what are the reuse or disposal procedures for empty drums/bags?</td>
<td></td>
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</tbody>
</table>
### Questions specific to the implementation of cleaner production:

3. Do you know the quantity of waste and emissions produced by each process and unit operation in your industry?

4. Do you keep your workflow clean and orderly to enable you to keep track of material handling and process operations?

5. Do you regularly use off-site recycling services/centers?

6. Have you determined whether raw materials in waste and emissions streams can be reclaimed?

7. Do you segregate process waste streams?

8. Do your employees know which processes generate wastes and emissions?

9. Does your operations plan include periodic cleaner production assessments?

10. Do you ask for Material Safety Data Sheets (MSDSs) to evaluate raw materials prior to purchase to ensure you are using the least toxic materials?

11. Do you limit your inventory stock to prevent possible spills, avoid over purchasing and other waste?

12. Do you request information regarding the types and qualities of waste and emissions generated by equipment you plan to purchase?

13. Do your purchasing agreements include provisions for inspecting shipments prior to acceptance to ensure they are not leaking or otherwise damaged?

14. Do you attempt to exchange wastes with other industries?

15. Can your fire suppression system handle a major emergency involving the chemical hazardous materials you have?

16. Are your storage areas designed to minimize earthquake damage, control spills and other mishap?

17. Are all of your workers trained on what to do in the event of a hazardous materials incident?

18. Does the industrial policy promote employee training and development in the area of cleaner production?

### Questions specific to the financial plan:

1. Do you consider the cost of waste disposal when developing profit and loss statements?

2. Do you know the waste and emissions production costs associated with the various processes of your industry?

### Questions specific to record keeping:

1. Do you keep records on the amount of raw materials used per process to monitor process efficiency?

2. Do you maintain logs on types and quantity of waste and emissions generated by your industry so that you can target areas for cleaner production?
3. Do you maintain Material Safety Data Sheets (MSDSs) on the materials used in your industry to help you identify possible waste and emissions streams?

4. Do you keep written policies and document standards for the plant operation procedures?

E. Questions specific to Marketing Plan.

1. Do you and your employees recognize the importance of proper management of hazardous materials, empties handling and cleaner production?

2. Do your marketing strategies incorporate the positive public image related to cleaner production?

3. Do you publicize your industry’s efforts to reduce waste and emissions?

The Project Team

All employees with questions or suggestions regarding the cleaner production assessment are encouraged to contact the leaders for cleaner production project.

Team Leader: _________________________________________________________________
Title: _________________________________________________________________________

Team Member: ________________________________________________________________
Title _________________________________________________________________________

The steps for Planning and Organization are:

- Get the management commitment and involvement.
- Set up a project team
- Establish goals
- Identify barriers for cleaner production.

1.1 STEP I: GET MANAGEMENT COMMITMENT AND INVOLVEMENT

Objective: To gain support for the cleaner production Assessment from the industry’s management.

Explanation: The management of the industry will support the cleaner production assessment when convinced of its benefits. The promoter/consultant should convince the management concerning to cleaner production. Without management commitment there will be no real action and no results.

i) Get management commitment

There are those industries interested in cleaner production because the managers and/or the owners of the industries take care of their operations, they are keen on a clean and properly organized working area, well kept production records, well maintained equipment and they show interests in solving workers problems.

Other industries are driven by market forces, taxes on resource consumption and/or waste and emissions towards the adoption of cleaner production practices. The cleaner production approach will give those industries a competitive advantage on emerging markets for environmentally improved products.
Stakeholders that could influence industry’s decision to adopt cleaner production are regulatory bodies, legislation & standards, local community, consumers and employees. Management commitment can be achieved by either emphasizing on the “care” principle or on the influence of market forces. To convince the management and obtain their commitment you have to:

- Highlight the economic benefits.
- Encourage responsible care.
- Highlight the environmental benefits.

The following arguments are used to convince the management to adopt cleaner production:

- Cleaner production lowers the cost of production, end – of – pipe treatment, health care and clean – up environment.
- Cleaner production lowers risk to workers, community, consumers of product, thus decreasing your liability costs and insurance preemies
- Cleaner production improved process efficiency and product quality thus contributing to industrial innovation and competitiveness.
- Cleaner production reduces regulatory fees.
- Cleaner production can enhance the industry’s public image (clean environmental record), producing intangible social and economic benefits.

ii) Get management involvement
After convincing the management, the promoter need to make sure that the management is committed and approves the cleaner production assessment. The management needs to remain involved throughout the assessment and implementation of cleaner production.

The management can show its involvement in the project of cleaner production by issuing a formal environmental policy statement which must come from the Director and be passed down and explained to the employees.

To get management involvement, you need to:

- Involve management in decision making.
- Keep management informed about the progress of the assessment.
- Make the benefits visible.
- Commit yourself to the success of the cleaner production assessment.

1.2 STEP 2: SET UP A PROJECT TEAM

Objective: To set the project team that will conduct the cleaner production assessment.

Explanation: The cleaner production assessment will affect a number of groups within the industry including representatives from all concerned sections in the project team.

1. Identify a team leader
A team leader needs to have sufficient authority to execute the program effectively. She/he has to be a champion of the good cause. The champion of the good cause helps to overcome resistance and is highly motivated and convinced of the success of the cleaner production assessment.
2. Select project team members

It is important to form a well balanced project team that can understand all aspects of the industry and its production process. The composition of the team will depend on the size and organization structure of the industry. Small industries may have a modest-sized team to carry out a cleaner production assessment. Supervisors & operators from the work floor may be included in the project team, since they are key persons to the program's success through their direct involvement with production process and their creativity can help in identification of cleaner production options.

An outsider may be included in the project team (optioned). The outsider can be from an industry association or a consultant who can bring new ideal and provide an objective viewpoint and is more likely to counteract bias due to the sacred cow syndrome.

Responsibilities of team members

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Responsibilities</th>
</tr>
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<tbody>
<tr>
<td>Management</td>
<td>Demonstrate corporate commitment.</td>
</tr>
<tr>
<td></td>
<td>• Set and enforce long-term goals.</td>
</tr>
<tr>
<td></td>
<td>• Have authority to implement changes.</td>
</tr>
<tr>
<td>Design/Engineering/Process</td>
<td>• Provide information on current processes.</td>
</tr>
<tr>
<td></td>
<td>• Contribute in proposing ideas for changing processes.</td>
</tr>
<tr>
<td></td>
<td>• Gauge the technical feasibility of proposals.</td>
</tr>
<tr>
<td></td>
<td>• Identify parameters for process optimization.</td>
</tr>
<tr>
<td>Environmental Compliance</td>
<td>• Calculate treatment and disposal costs.</td>
</tr>
<tr>
<td></td>
<td>• Ensure compliance with regulations.</td>
</tr>
<tr>
<td>Finance/Purchasing</td>
<td>• Calculate costs of current operations.</td>
</tr>
<tr>
<td></td>
<td>• Calculate costs and savings of proposals.</td>
</tr>
<tr>
<td></td>
<td>• Track cost and benefits of actual changes.</td>
</tr>
<tr>
<td>Sales &amp; Marketing</td>
<td>• Provide insight into customer needs.</td>
</tr>
<tr>
<td></td>
<td>• Educate customers about cleaner production changes.</td>
</tr>
<tr>
<td></td>
<td>• Market products as environmentally responsible.</td>
</tr>
<tr>
<td></td>
<td>• Monitor customer reactions to product changes.</td>
</tr>
<tr>
<td>Production Workers</td>
<td>• Provide accurate descriptions of production practices.</td>
</tr>
<tr>
<td></td>
<td>• Suggest ideas on new approaches.</td>
</tr>
<tr>
<td></td>
<td>• Supply feedback on frontline effects of changes.</td>
</tr>
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<td></td>
<td>• Increase workers support for production line changes.</td>
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3. Tasks of the project team.

The most important tasks of the project team are to:-

• Analyze and review present practices (knowledge)
• Develop and evaluate changes (creativity)
• Implement and maintain changes (authority)
Other tasks of the project team are:

- Obtains the involvement of senior management and makes sure that the management issues a documented cleaner production policy.
- Documents its activities and keeps the industry informed about the progress made.
- Sets overall cleaner production goals.
- Set up a waste materials recording system.
- Sets the assessment focus on certain waste streams and sections of the production process.
- Formulates individual tasks if necessary.
- Performs (or supervises) the assessment.
- Performs (or supervises) technical/financial feasibility analyses of suitable options.
- Selects suitable options for implementation.
- Monitors the results of the option as soon as it becomes operational.
- Ensures a continuation of cleaner production activities.

4. **Divide the project team**

Divide the project team into a core group with specific tasks, existing of personnel which have good knowledge of the production process at the work floor level. Participation of work floor personnel in the production activities is important. The success will however, depend on traditions and the culture of the industry and the conditions for the employee participation established in the project.

5. **Employee participation**

Job security, addressing of occupational health and safety issues and participation in environmental training during the cleaner production assessment, is a motivation to employees to take part in cleaner production implementation. Involve employee participation in ad hoc groups whose participation might be organized in different ways depending on the activity such as planning, co-ordination, data collection, option generation and assessment. Project team members could be chosen because of their environmental interest and knowledge or because of their department is involved in cleaner production assessment. The best way for employee participation is to involve them in the departments, to take part in meetings, activities and membership of a project or task force.

1.3 **STEP 3: ESTABLISH GOALS**

**Objective**: Industrial cleaner production goals should be set which will function as guidelines for cleaner production assessment.

**Explanation**: The assessment can easily become an exercise without an aim if the industry cannot set goals. The goals will be refined as the project team gains insight for cleaner production.

1. **Formulate cleaner production goals**

The cleaner production goals should be realistic enough to serve as an appropriate measure of success in each unit operation. The goals will evolve from qualitative directives to quantitative aims as the cleaner production assessment process.

2. **Focus cleaner production goals**

The cleaner production goals should base on:-
- Historical production data.
Cleaner Production Implementation Manual

- Technology benchmarking.
- Internal productivity standards.
- Environmental legislation.

The worksheets to evaluate industrial procedures are tools for setting cleaner production goals.

3. Criteria for setting cleaner production goals
The cleaner production goals should be made quantitative in order to be used later to evaluate the success of the programme. The goals should be:
- Flexible and adaptable to changing requirements.
- Acceptable to those who will work to achieve them.
- Motivational.
- Measurable over time.
- Understandable with a practical level of effort.
- Suitable to the overall statement of management policy.

The following are the criteria for formulating cleaner production goals:
- Cost for labor, maintenance and inputs.
- Chemical reactivity.
- Air emissions.
- Waste generation.
- Health effects.
- Disposal cost.
- Disposal method (recycling on or off site, landfill).
- Known substitutes / alternatives.
- Flammability.

4. Making a Plan
The project team has to make a plan basing on short and long term objectives. The plan should include a time schedule for activities, a division of responsibilities and a tentative end-of – project date.

The worksheets for planning and organization should be filled in, stating the members of the team and goals for cleaner production assessment.
Planning should be flexible so that adjustments can be made as cleaner production goals are refined during the pre-assessment and assessment phases.

1.4 STEP 4: BARRIERS

Objective: To identify and overcome the barriers that may inhibit or slow down cleaner production assessment activities.

Explanation: The project team must be aware of the barriers and find solutions to overcome barriers to cleaner production since they can lead to conflicts within the industry and endanger progress of
cleaner production assessment.

1. **Identify barriers**

   Identify barriers in the following areas:-
   - Lack of information
   - Technical barriers
   - Prevailing attitudes
   - Economic barriers
   - Organizational barriers
   - Governmental barriers
   - Systematic barriers

   **Lack of information**
   This is very common to the industry which has no culture for educating the employees. If the industry has no culture for educating employees, a change in behavior required for cleaner production option implementation will meet a lot of resistance.

   **Technical barriers**
   Although technology is not a big factor that should seriously limit adoption of cleaner production but sometimes technical expertise do impede the changeover to cleaner production practices.

   **Prevailing attitudes**
   Barriers are the result of misunderstandings and resistance to change. Some industries maintain their present situation and fear that cleaner production adoption will not work as expected. They lack leadership, effective supervision, good housekeeping culture, job security and fear of failure.

   **Economic barriers**
   The top management is interested in making profit and not loss, so more emphasis is on production and not waste minimization. Availability of finances, cost of human natural resources and economic policies affecting the industry may hinder implementation of cleaner production. Investment on time, money, human resources has to be made to start cleaner production assessment, but the management may not want to invest in cleaner production. So, it is advisable to start with cleaner production options which do not need investment.

   **Organization barriers**
   The barriers are related to the allocation of human, financial resources, lack of cooperation and coordination between individuals, functions inside and outside the industry. In some industries there is a centralization of decision making. In such industries all decisions are made by the Chief Executive who is the owner of the industry. Therefore, personnel from departments do not participate in waste minimization and environmental management activities unless ordered by the Chief Executive himself/herself. Moreover, lack of motivation to employees can greatly hinder cleaner production implementation.

   **Governmental barriers**
   Regulatory authorities emphasize on end of pipe control approach rather than adopting cleaner
production concept approach. Also, frequent changing of industrial policy is not conducive to waste minimization efforts.

Systemic barriers
Poor record keeping and reporting, inadequate and ineffective management systems are big systemic barriers. Also, lack of public pressure for controlling pollution may make the industry not see the importance of adoption of cleaner production.

Identify solutions for barriers
The first step to overcome barriers is to raise awareness about the benefits of cleaner production. Different approaches are used to solve barrier problem as follows:-
• Present cleaner production as a challenge for positive industry development.
• Collect information on successfully implemented alternative technologies or substitutes
• Stress that no or low cost changes can easily be implemented.
• Evaluate the economics of energy, waste and emissions, and coincide them as potential resources.
• Collect information on cleaner production from database, innovation or information centers.
• Present cleaner production as an integrated part of the product and process development.
2.0 Phase II - Pre-Assessment

**Objective:** To select one or a few assessment focuses.

**Results:**
- Provisions for before and after comparison are made.
- Process flow chart development.
- No or low cost cleaner production options implemented.

**Worksheets for pre – assessment phase are:-**
- Checklist for pre – assessment.
- Design of a process flow chart.

**Check list for the pre- assessment**
This check list can be used to help organize the Pre-Assessment Phase. It can be used again at the end of this phase to evaluate whether all important issues of this phase have been addressed.

In case a positive answer, it implies that a report of other information is available. The information should be enclosed in the files of cleaner production assessment.

<table>
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<tr>
<th></th>
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<th>YES</th>
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<th>NOT SURE</th>
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<tr>
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<td>Have you identified information sources outside the industry?</td>
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<td>3.</td>
<td>Were all project team member engaged in the a walk –through of the industry?</td>
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<td>4.</td>
<td>Have you documented the findings and results of the Walk-through?</td>
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<td>5.</td>
<td>Have you developed a process flow chart?</td>
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<td>6.</td>
<td>Have actions been taken to install a monitoring and analysis system allowing a ‘before-and-after’ comparison of the cleaner production options?</td>
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<td>7.</td>
<td>Have obvious no cost cleaner production options been implemented?</td>
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<td>8.</td>
<td>Have you prepared ‘before-and-after’ sheet for this options?</td>
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<td>9.</td>
<td>Have you calculated the pay-back period of these options?</td>
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<td>10.</td>
<td>Has the focus for the cleaner production assessment been set?</td>
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<td>11.</td>
<td>Have you evaluated and refined the cleaner production goals?</td>
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<td>12.</td>
<td>Have you adjusted the planning and time schedule for cleaner production assessment?</td>
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<td>13.</td>
<td>Have you informed the management and employees about the progress of the cleaner production assessment?</td>
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<tr>
<td>14.</td>
<td>Have you changed the composition of the project team in anticipation of the following steps?</td>
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</table>
2.1 STEP 5: DEVELOP A PROCESS FLOW CHART

Objective: To develop a process flow chart, describing the entire facility, showing all steps through which raw materials pass to form a product.

The flow chart has three parts; inputs, unit operation and outputs. Inputs are raw materials, auxiliaries and energy, while outputs are waste, emissions and end products.

Explanation: The project team should familiarize itself with the manufacturing process including storage facilities, utilities, waste treatment and disposal facilities.

1. Collect documented information
All existing documentation and information regarding the processes in the industry need to be collected and reviewed. Prior plant survey may help to get useful information for concerned areas. The following questions are used as guidelines for getting useful documents:-
   • Are any process flow charts available?
   • Are energy consumption and process waste and emissions monitored?
   • Do you have a map of the surrounding area indicating a sewer – plan, hydrology, human settlements and water course?
   • Is the site plan available?
   • Are there any other factories in the area which have similar processes?

Also collect data and information on the following:-
   • What raw materials end up in the emission and waste stream?
   • What are the waste and emissions associated with your process?
   • Which processes do these waste and emissions come from?
   • Which waste and emissions are classified as hazardous and which are not hazardous?
   • Where are raw materials, energy and auxiliaries used in great quantities?
   • Do you use chemicals that have special instructions for their use and handling?
   • Do you have waste and emissions treatments?
   • What are the disposal costs?
   • Where are your discharge points for liquid, solid waste and gaseous emissions?

2. Collect information during a walk – through
A walk – through is a visit to the work floor by which the project team gains familiarity with the plant and the unit operations.

The benefits for walk – through visits are:-
   • To bring all team members equally up-to-date on the operations.
   • To document and verify the process flow charts.
   • Identification of other industry personnel who have specific knowledge or ideas.
   • Easy identification of options for cleaner production.

The schedule for walk – through should be when all unit operations are in operation. More walk – through should be scheduled to account for seasonal variations in production and review cleaning and
maintenance. When performing the work – through, follow the process from the storage area to the point where the products, waste and emissions leave the area. Talk to employees on the work floor to get information useful in characterizing unit operation and identify options for cleaner production. Pay attention to no or low cost cleaner production options which can be implemented immediately. Use the check list questions during the walk through.

Questions to be answered during the walk-through are:-

- Does your industry show sign of poor housekeeping, cluttered walk ways, un-swept floors, uncovered material drums etc?
- Are there noticeable spill, leaking containers or is water dripping or running?
- Is there discoloration or corrosion on walls, work surfaces?
- Do you smell strange odor, or experience, noise or throat irritation when first enter the work place?

These symptoms might indicate system leakage.

- Do you see smoke, dirt fumes to indicate, material losses?
- Is there any out-dated stock that is not in use?
- What are the storage procedures?
- Are all container labeled as to their contents and hazard?
- Do you notice waste and emission being generated from processes in your industry [dripping water or steam leakage, evaporation, drag –out]?
- Is there a history of spills, leaks, accidents or fire in your industry? Which processes were involves?
- Do employees have any comments about the sources of waste and emissions in the industry?
- Are emergency equipments [fire extinguishers, etc] available and visible and to ensure rapid response to a fire or other accident?

3. **Develop the process flow chart**

The process flow chart for pre-treatment section in a textile company is shown here below;

The process flow chart is the key step in the entire analysis and it forms the basis for compilation of material and energy balance. Highlight the free or less costly inputs like water, air which are major causes of waste and emissions. The chart should list, characterize the input and output streams, taking in account of the recycle streams. The process flow chart could be supplemented with chemical equations to facilitate understanding of the process. Materials which are used occasionally and do not appear in the output stream (e.g. catalysts) should be considered.
Figure 1: Design of a process flow chart

Figure 2: Flow chart for Spinning
Figure 3: Flow chart for Weaving
Figure 4: Flow chart for Processing
Figure 5: Flow chart for Knitting

YARN

- Beaming
- Knitting

Dyes & Auxiliaries

- Dyeing

Chemicals

- Finishing & Conditioning
- Fabric cutting

- Stitching
- Bailing

Solid waste
Liquid waste
Liquid waste
Solid waste
Solid waste

Figure 6: Flow chart for the boiler

- H₂O
- CO₂, SO₂

- Oil

- Electric Energy

BOILER

- Gaseous emissions;

- Steam

Figure 6: Flow chart for the boiler
2.2  **STEP 6: EVALUATE INPUTS AND OUTPUTS**

**Objective:** To determine whether the qualities of the inputs results in reasonable quantity of outputs.

**Explanation:** By looking at how much inputs are converted into products, how much into waste and how much auxiliaries are needed during production and by doing so you can determine whether the process is efficient or not. These findings are used to set focus of the cleaner production assessment.

This step gives rough estimate of quantities of raw materials auxiliaries, products, by product, waste and emissions consumed or produced by each process or unit operation.

The evaluation is based on simple calculation. At this stage, data on the quantities and composition of inputs and outputs should be recorded periodically so that ‘before- and- after’ comparison of cleaner production option can be made. The data is also used to derive material balance during the assessment phase.

2.3  **STEP 6A: EVALUATE OCCUPATIONAL HEALTH AND SAFETY**

**Objective:** To make an overall evaluation of occupational health and safety at the industry.

**Explanation:** Emphasis on occupational health and safety is a motivation to employees to contribute to cleaner production implementation. Occupational health and safety is part of cleaner production.

Occupational health and safety is a managerial issue. The management should try to provide protective gears to employees in order to avoid sickness which will cause absenteeism and should develop human resources of employees in order to improve the dynamics and competitiveness of the industry.

Occupational health and safety is understood as:-
- Safety at work.
- Health at work.
- Sickness absence.

Elements of work that have impact on occupation health and safety are:-
- Exposure to chemical substances as dust, liquid, vapor or aerosols or exposure to micro – organisms.
- Noise and vibrations.
- Temperature, light and humidity.
- Ergonomic conditions.
- Accident risks.
- Risk for accidents at work.

Occupational health and safety is a managerial as well as a social issue. It can be assessed by the employees, safety officer or factory inspector. Different tools might be used for assessment such as; job observation, interviews or group discussion to reveal the working environment and working conditions of employees in each department. The discussion should focus on health risks, the symptoms and inconveniences the employees claim. They may fill the work sheet for occupational health and safety in
order to get the right information on health and safety of the employees. Chemicals, noises, vibrations, working load, temperature, humidity, light and accidents are big factors which contribute much on occupational health and safety of employees.

**Explanation to work sheet for occupation health and safety**

**Chemical impacts:**

State
- The chemicals that are used.
- How the employees are exposed to the chemicals (through skin, breathing or through the mouth).
- The form of indoor air pollution.

**Noises:**

Report
- The source of noise.
- What has been done to prevent noise at the source?
- If ear protection is provided and used.
- The noise level.

**Vibrations:**

Report
- The source of vibrations.
- What has been done to prevent the vibrations at the source?

**Working load:**

Report
- If items are lifted, carried or pushed around and how this is done.
- Describe how often the lifting, carrying and pushing is done.
- Estimate the weigh and the work speed.
- How often the work is done per day.

**Other issues:**

Report and describe conditions concerning;
- Space.
- Temperature.
- Humidity.
- Accidents.
- Light.

2.4 **STEP 7: SET CLEANER PRODUCTION ASSESSMENT FOCUS**

**Objective:** To set the focus for cleaner production assessment based on the results of step 5 and 6.

The setting of the focus for the cleaner production assessment is basically a refinement of the cleaner production goals which have been defined during the planning and organization phase. Selection of
processes unit operations has to be made for reasons of practicality.

The information which is collected during the pre – assessment phase should be documented because this information:-
• Is a prerequisite for the assessment?
• Is crucial for the ‘before- and- after’ comparison after cleaner production options have been implemented.
• Can be helpful for next time when cleaner production assessment is conducted.

The focus of cleaner production assessment should be on the area which;
• Creates a high quantity of waste and emissions.
• Causes high economic loss.
• Is accepted by all persons involved.
• Has numerous obvious cleaner production options.

Criteria for setting the Assessment focus
• Magnitude of environmental and occupational health hazard.
• Costs of raw materials.
• Compliance with present and future regulations.
• Costs of waste and emissions management (treatment and disposal).
• Quantity of emissions and wastes.
• Energy consumption.
• Hazardous properties of waste and emissions (including toxicity, flammability, corrosivity).
• Potential for recovery of valuable by-products.
• Available budget for cleaner production assessment.
• Expectations regarding future competitiveness.
• Potential subsidies or grants for investment in cleaner technologies.
3.0 Phase III - Assessment

Objective: To develop a set of cleaner production options and identify those options which can be implemented immediately and those which need more detailed analysis.

Results: To derive and check material balance, to get a detailed understanding of the sources and causes of waste, emissions obtained and to generate a comprehensive set of cleaner production options listed in their priority.

The following check lists are used for the assessment phase:

- Assessment worksheet is used to help organize and evaluate the assessment phase.
- Worksheet for Material balance can be filled in when inputs and outputs have been investigated and costs have been assigned. The material balance should be for unit operations.
- Cost of waste and emission stream work sheet should be prepared. It helps the management to gain confidence and commitment for cleaner production after knowing the loss caused by waste generated.
- The cause assessment worksheet is used to document causes of waste streams and it can be used again for generation of options.
- Cleaner production options worksheet is used during the brainstorming sessions to list all cleaner production options which are generated.

Check list for the assessment

This checklist can be used to help organize the assessment phase. It can be used again at the end of this phase to evaluate whether all important issues of this phase have been addressed. If the answer is positive it implies that a report of other information is available. The information has to be enclosed in the files of cleaner production assessment.

<table>
<thead>
<tr>
<th></th>
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<th>NO</th>
<th>NOT RELEVANT</th>
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<tbody>
<tr>
<td>1.</td>
<td>Have you derived material balances for all unit operation which are the focus of the assessment?</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>2.</td>
<td>Have you put costs to all elements of the material balances?</td>
<td>[ ]</td>
<td>[ ]</td>
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<tr>
<td>3.</td>
<td>Have you pinpointed the causes and sources of wastes and emission and energy losses in your industry?</td>
<td>[ ]</td>
<td>[ ]</td>
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<tr>
<td>4.</td>
<td>Do you understand the causes of waste, emissions generation and energy losses in your industry?</td>
<td>[ ]</td>
<td>[ ]</td>
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<tr>
<td>5.</td>
<td>Have you collected and documented information on cleaner production option?</td>
<td>[ ]</td>
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<tr>
<td>6.</td>
<td>Have you conducted a brainstorming session?</td>
<td>[ ]</td>
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<tr>
<td>7.</td>
<td>Are all identified cleaner production options documented</td>
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<tr>
<td>8.</td>
<td>Have you ordered the options?</td>
<td>[ ]</td>
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<tr>
<td>9.</td>
<td>Have you prioritized the options considering their availability, suitability, environmental effect, and the economic effect?</td>
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<tr>
<td>10.</td>
<td>Have you implemented obviously feasible options with no and low costs?</td>
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<tr>
<td>11.</td>
<td>Have you prepared ‘before- and –after’ sheets for these options and determined the payback period?</td>
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<tr>
<td>12.</td>
<td>Have you evaluated and refined the cleaner production goals?</td>
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</tbody>
</table>
13. Have you adjusted the planning and the time-schedule for the assessment?

14. Have you informed the management and employees about the progress of the cleaner production assessment?

15. Have you adjusted the composition of the project team in anticipation of the needs for the following steps?

### Worksheet for Cost of Waste and Emission Streams

<table>
<thead>
<tr>
<th>Waste and emissions stream</th>
<th>Operation Unit</th>
<th>Cost of product loss (per year)</th>
<th>Cost of raw material loss (per year)</th>
<th>Environmental cost (per year)</th>
<th>Total Cost (per year)</th>
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<td>Solid Waste</td>
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<td>1</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td>Wastewater stream</td>
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<tr>
<td>Gaseous emissions</td>
<td></td>
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<td></td>
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<td>Energy losses</td>
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<td></td>
<td></td>
<td>2</td>
<td></td>
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</table>

### Worksheet for Cleaner Production Options

<table>
<thead>
<tr>
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<th>Operation Unit</th>
<th>Cleaner Production Approach</th>
<th>Could be applied in order to:</th>
<th>By means of:</th>
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<td>Change in input materials;</td>
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<tr>
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<td></td>
<td>2</td>
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<tr>
<td>1.</td>
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<td>2</td>
<td></td>
<td></td>
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<tr>
<td>Good operating practices</td>
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</tr>
<tr>
<td>1.</td>
<td></td>
<td>2</td>
<td></td>
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<tr>
<td>Product changes</td>
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</tr>
<tr>
<td>1.</td>
<td></td>
<td>2</td>
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<tr>
<td>On site reuse</td>
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<td>1</td>
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<td>1.</td>
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</table>
3.1 **STEP 8: DERIVE A MATERIAL BALANCE**

**Objective:** To account for the use of raw materials, auxiliaries and energy that go into the Process and that is released by the same process.

1. **The purpose of material balance**
   
   The material balance helps in identifying and quantifying unknown losses or emissions. The process flow chart forms the basis for calculation of the material balance. The material balance gives an insight into source and causes of waste and emissions. The insight is needed for generation of cleaner production options.

   The material balance gives insight of the inputs and outputs costs. By knowing these costs, it becomes possible to convince the management to agree and implement cleaner production options of choice. Include a person with relevant engineering background to assist in deriving the material balance. Material balance is used to monitor the improvements made by the industry after introducing cleaner production options.

   Direct and indirect cost components associated with waste and emissions are;
   
   - Cost of raw materials in waste and emissions.
   - Cost of energy in products, waste and emissions.
   - Cost of maintenance.
   - Cost of waste and emissions treatment to comply with regulatory requirements.
   - Cost of transport and disposal of waste.
   - Costs of potential necessary additional installation and other adjustments.

   Material balances are useful for;
   
   - Monitoring the improvements made after introducing cleaner production options.
   - Evaluating the costs and benefits of a process.

2. **Principles of material balance**
   
   Material balance is drawn up according to the mass conservation principle which states that;

   \[ \text{Inputs} = \text{Outputs} \]

   Inputs are raw materials, auxiliaries, water and energy while outputs are products, by-products, waste and emissions.

---

**Figure 7: Components of material balance of a process or unit operation**
Information sources for deriving a material balance

- Purchase records
- Material inventories.
- Batch composition records.
- Production information of suppliers.
- Product specification.
- Standard operating procedures and operating manuals.
- Sample, analysis and measurement of inputs and outputs.
- Energy bills.
- Emission inventories.
- Equipment cleaning and validation procedures;
- Waste and emission forms.
- Literature and consultants.
- Interviews with work-floor employees to check if operations are done according to the prescriptions.

3. Set the box for material balance

Before deriving the material balance, the unit operation must be defined carefully. Material balances are easier, more meaningful and more accurate when they are done for individual unit operations. The material balance for the entire industry can be constructed from the material balances of individual unit operations.

Quantify the volume and composition of all material flow which could result in material balance for all individual unit operations or for the entire industry.

4. Investigate the inputs

When investigating inputs the following breakdown should be made:-

- Raw materials and auxiliaries.
- Water.
- Energy.

Raw material and auxiliaries

Generally the following questions should be answered for raw materials and auxiliaries:

- What raw material and auxiliaries are used in the process?
- What is their function in the production process?
- In what quantities are they used?
- What are the costs of the raw materials and auxiliaries?
- What hazardous characteristics do they have for humans and the environment?

Water

- Where is water used in the process?
- At what quantity?
- What is the cost of water consumption?
- What is the water source?
- What is the storage capacity on site?
- Is rain water a significant factor on site?
- Why is water used in each process?
Using less water can be a cost saving exercise.

**Energy**
- Where is energy consumed in the process?
- What is the function of the energy in the process?
- In what quantities is energy consumed?
- What are the costs of energy consumption?

Sometimes energy and material balance are separated.
If there are no meters to measure energy consumption, you can look at how much kilo watts an equipment uses according to its prescriptions.

5. **Investigate outputs**
The outputs are broken down into the following categories:
- Products and by-products.
- Waste and emissions.
- Energy.

**Products and by-product**
The following questions are to be answered for products and by products;
- What are the products and by-products?
- In what quantities are they produced?
- What are the hazardous components?
- How high the product loss is and what are the costs associated with this loss?
- Is there a recycling unit for rejected products?

Information about product composition and the quantity of the product which is produced is used to gather information about the amount of inputs converted into the product. Information about the composition of the product can be found by reviewing job sheets, customer specifications, quality control data and product data sheets. For quantity produced the information can be found in sales records of products.

The by product can be reused within the production line or sold to the market as a raw material or as a product.

6. **Waste and emissions**
Waste and emissions data can be obtained by answering the following questions;
- What waste and emissions are being generated?
- In what quantities are they generated?
- What are the costs associated with the waste and emissions?
- What are the waste and emissions composition and hazardousness to humans and the environment?

Measuring of the composition and quantity of waste and emission must be done periodically. Changes in waste and emissions cannot be accurately measured unless the information is collected before and after implementation of cleaner production option.
Costs of waste and emissions are based on:–
  • Internal recycling.
  • Disposal and treatment.
  • Loss of raw materials and auxiliaries.
  • Energy, raw materials and auxiliaries losses.
  • Penalties for exceeding limits.
  • Costs of maintenance, cleaning (non-productive hours).

There are three categories of wastes and emissions:-
  • Solid wastes and sludge.
  • Wastewater or liquid waste.
  • Gaseous emissions.

Sometime the process can be associated with energy loss.

i) Solid wastes and sludge
These are wastes which do not end up in wastewater. Their quantity is measured different from wastewater.

The following questions can be helpful in obtaining the quantity of solid waste and sludge.
  • Where does the waste originate from?
  • Could the manufacturing operations be optimized to produce less waste?
  • Could alternative raw materials be used which would produce less waste?
  • Does the waste contain valuable materials?
  • Can the waste be recycled?
  • Is there any particular component that renders the whole waste hazardous?
  • Could this component be isolated?

Some solid wastes can be directly reused in production and others require some modification before they are suitable for reuse.

ii) Waste water or liquid waste
Large quantities of waste water are discharged into the sewer or to the water course. Waste water from textile industries has big impact to the environment because textile manufacturing is one of the most water intensive industrial processes.

The wastewater normally contains valuable unused raw materials. Measuring of raw materials it carries is crucial for a completion of material balance. The sum of waste water generated from each unit operation should be approximately being the same as that of the input to the process.

In order to carry out a survey on waste water flow, the following key points need to be observed;
  • Identity the effluent discharge points.
  • Identify where flows from different unit operations or process areas contribute to overall flow.
  • Identity waste water treatment facilities and recycling streams.
• Plan your monitoring program thoroughly and try to take sample over a range of operating conditions such as full production, start up, shut down and washing out.

iii) Gaseous emissions
Gaseous emissions can constitute a considerable loss of inputs. So it is important to consider carefully when deriving material balance. Measuring of gaseous emissions is difficult but by using the following indicators it is easy to reveal gaseous emissions:-
  • Are odors associated with a unit operation?
  • Are there certain times when gaseous emissions become more prominent, are they linked to temperature?
  • Do employees wear protective gears such as masks, protective clothing?
  • Is there any pollution control equipment in place?
  • Are gaseous emissions from a confined space vented to the outside?
  • If gas scrubbing is practiced, what is done with the spent scrubber solution? Could it be converted to useful product?

iv) Energy
Concerning energy, you need to know about:-
  • What energy losses are there?
  • How big are the energy losses?
  • What costs are associated with these losses?

Energy in textile industries is a significant cost element for most of the production units. Energy can be lost in many ways, such as:-
  • Energy in radiation.
  • Energy in cooling water.
  • Energy in hot products and residues.
  • Energy in condensate formation.

7. Derive the material balance for the entire process
Material balance of one unit enables someone to identify ways to improve the efficiency of that particular unit operation. The insight in waste and emissions is used to improve waste management practices. Insight in material balance of the entire process is used to follow the material throughout the process and identify ways to improve production efficiency, improve waste management practices, prevent waste and emissions and segregate or recycle waste streams.

8. Evaluate and refine the material balance
Evaluation of the material balance is done basing on the following guidelines:-
  • Derive material balance for the entire process.
  • Material balance becomes more meaningful if it is made for each material separately.
  • Check the consistency of units used.
  • Time frame for material balance should be a representative period.
Material balance worksheet for a single unit operation

The worksheet can be used to derive a material balance of a single unit operation during the assessment.

<table>
<thead>
<tr>
<th>In</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs (per year)</td>
<td>Costs (per year)</td>
</tr>
<tr>
<td>Quantity (per year)</td>
<td>Quantity (Per year)</td>
</tr>
<tr>
<td>Raw Materials,</td>
<td>Product, By Product,</td>
</tr>
<tr>
<td>Auxiliaries, Energy</td>
<td>Energy, Waste, Emissions</td>
</tr>
<tr>
<td>..................................</td>
<td>..................................</td>
</tr>
<tr>
<td>Date of first measure:</td>
<td>Date of first measure:</td>
</tr>
</tbody>
</table>

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**Material balance worksheet for a single unit operation**

The worksheet can be used to derive a material balance of a single unit operation during the assessment.
3.2 STEP 9: CONDUCT A CAUSE ASSESSMENT

**Objective:** To pinpoint the sources and causes of waste emission and energy losses.

The material balance should give the insight in where, why and how much waste and emissions have been generated and how much energy has been lost.

Questions on where do waste, emissions and energy losses occur (source)? And why do they occur (cause) should be answered. Use worksheet for cause assessment to identify causes for waste and emissions generation.

Raw material, technology, operating practices, products, waste and emissions are features for the process and they can help in identifying the place and causes for the generation of waste and emissions.

![Figure 8: Five features of a process](image)

**Work sheet for Cause assessment**

<table>
<thead>
<tr>
<th>Waste and Emissions stream</th>
<th>Operation Unit</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Possible waste sources</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material;</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td></td>
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<td>2.</td>
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<td>3.</td>
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<tr>
<td>Operation practices;</td>
<td></td>
</tr>
<tr>
<td>1.</td>
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<td>3.</td>
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<tr>
<td>Product</td>
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<tr>
<td>1.</td>
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<td>3.</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td></td>
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<tr>
<td>2.</td>
<td></td>
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<tr>
<td>3.</td>
<td></td>
</tr>
</tbody>
</table>
Causes for waste, emissions for different features

Causes related to technology
• Unchecked water / air consumption.
• Lack of preventive maintenance.
• Leaking taps / valves.
• Spillages from transfer belts, pipes.
• Lack of information.

Causes related to raw materials
• Use of substandard cheap raw materials.
• Lack of quality specifications.
• Improper purchase management system.
• Shortage of supply.
• Improper storage.

Causes related to operating practices
• Fear of losing trade secrets.
• Understaffing hence work over-pressure.
• Increased dependence on casual / contract labor.
• Lack of recognition.
• Lack of commitment and attention by top management.
• Lack of formalized training.
• Absence of reward/punishment system.
• Lack of commitment and attention by top management.
• Emphasis on production only and not people.

Causes related to products
• Inefficient ratio between products and by – products.
• Impractical product design.
• Packaging.
• Product composed of hazardous materials.
• Too high quality specifications.

Causes related to waste
• No waste segregation.
• Improper handling.
• No recovery of energy in product waste and emissions.
• Disregard potential for reuse or recycling of certain wastes.

3.3 STEP 10: GENERATION OF CLEANER PRODUCTION OPTIONS

Objective: To generate a comprehensive set of cleaner production options.

Once the sources, causes of waste and emissions are known, the cleaner production assessment enters
the creative phase. With the process flow chart and material balance at hand, you can choose the unit operation, material, waste or emissions streams which you want to make subject to cleaner production changes most urgently.

**Figure 9: Process elements for cleaner production option**

**Raw material change**
The aim of raw material change is to reduce or eliminate hazardous materials that enter the production process. The raw materials can be purified or substituted to reduce hazardous wastes.

**Technological change**
Technology changes are oriented towards process and equipment modifications to reduce wastes and emissions, preliminary in a production setting. Technological change includes changes in process conditions such as flow rates, temperatures, pressures, equipment modification and use of automation.

**Good operating practices**
Good housekeeping practices are procedural, administrative, or institutional measures that an industry can use to minimize waste and emissions. Good operating practices can be implemented with little cost. Good operating practices include:-

- Material handling and inventory practices.
- Loss prevention.
- Waste segregation.
- Cost accounting practices.
- Training of employees.
- Production scheduling.

**Product change includes;**
- Change in quality standards.
- Product substitution.
- Change in product composition.
- Product durability.

Product changes can lead to changes in design or composition on order to make the product environmentally safe through its life cycle from raw material to final disposal.
On-site reuse and recycling
Recycling or re-use of the waste material involves the return of waste material to the originating process as a substitute for an input material or to another process as an input material. Brain storming is another technologic to obtain cleaner production options.

CLEANER PRODUCTION OPTIONS GENERATION IN RELATION TO OCCUPATIONAL HEALTH AND SAFETY.

Options should be generated for activities with major occupational health and safety problems, taking into account the possibilities for minimization of the impact on internal and external environment. Possibilities for improving occupational health and safety conditions for workers and the environment should be taken into account.

Also generation of the options should be based on causes of where and when does the exposure occur and why does the exposure occur. The causes of problems in relation with occupational health and safety might be related to technology, raw materials, products, operating practices and handling of wastes.

Refer: Cost of wastes and emissions stream sheet.

Minimization of chemical (and biological) hazards
Exposure to chemical hazards should be prevented through considering the following options:-
• Change in raw materials and other chemicals to less toxic chemicals.
• Minimization of change of process conditions or state of chemicals.

Minimization of exposure through prevention by:-
• Use of protective gears.
• Employee training.
• Change of process conditions.
• Change state of chemicals.

Minimization of noise and vibrations
The exposure to noise and vibration should be considered through the following hierarchy:
• Prevention at source.
• Reduction of spreading and transmission of noise and vibration.
• Reduction of exposure through use of personnel protective equipments.
• Reduction of exposure through change of working routines.

Minimization of working load
The working load can be limited through:-
• Job rotation.
• Installation of helping equipments to reduce heavy lifting and carrying.
• Arrange work according to the physical status of an employee.
3.4 STEP 11. SCREEN OPTIONS

Objective: To select and prioritize the cleaner production options for further study. After generating enough options, most promising options should be submitted for a feasibility study.

1. Prioritize options.
   Criteria for prioritizing options:

   **Environmental Effect**
   - What is the anticipated environmental effect of the option?
   - How big is the estimated reduction in the waste stream or emission?
   - Will the option affect public or worker health?
   - If so, what is the magnitude of these effects in terms of toxicity and quantity (positive/ negative)?

   **Economic Feasibility**
   - What are the anticipated costs and benefits from implementing the option?
   - Can you estimate the required investment?
   - Can you make an estimate of the benefits, such as reduction of environmental costs, reduction in wastage and/or improving the quality of the product?

   **Availability**
   - Is the cleaner production option available?
   - Can you find a supplier who can supply you with the necessary equipment or input material?
   - Do you know an advisor who can help you develop an alternative?
   - Has the cleaner production option already been applied elsewhere?
   - If so, what are the results and experiences?

   **Suitability**
   - Does the option fit in with the way your industry is run?
   - Is the option in line with your industry’s product?
   - What are the consequences of the options for your internal logistics, throughout time and production planning?
   - Does the option require adjustments in other parts of the industry?
   - If so, what adjustments?
   - Does the change require additional training of staff and employees?

1. Order options in coherent packages
   In ordering the options, the following activities should be done:
   - Organize the options per unit operation those obtained during brainstorming.
   - Evaluate obvious mutual interferences to avoid interferences across unit operations.
   - Implement feasible options which have low and which seem to be cost – effective and easy to implement.
   - Eliminate non-feasible options which are very expensive to implement.
4.0 Phase IV- Feasibility Study

Objective: To select cleaner production for implementation.

Options don’t need a through feasibility study because their benefits are obvious. For most industries, the economic evaluation will be most important. The consultant can help to provide the information needed to conduct the feasibility study and give the project team advice on which options to select for implementation.

Worksheets for feasibility study
The following are worksheets for feasibility study:-
• Checklist for feasibility study.
• Technical evaluation.
• Economic evaluation.
• Environmental evaluation.
• Select feasible options – the worksheet is used to select the options for implementation.

Checklist for feasibility study
This checklist can be used to help organize the feasibility study phase. It can be used again at the end of this phase to evaluate whether all important issues of this phase have been addressed. In case of a positive answer it implies that a report of other information is available enclose this information in the files of the cleaner production assessment.

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
<th>NOT RELEVANT</th>
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</thead>
<tbody>
<tr>
<td>1. Have you conducted a technical evaluation for the prioritized options?</td>
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<tr>
<td>2. Have you conducted an economic evaluation for the prioritized options?</td>
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<tr>
<td>3. Have you conducted an environmental evaluation for the prioritized options?</td>
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<td>4. Have you determined what training needs for employees are needed for a successful implementation of the selected options?</td>
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<tr>
<td>5. Do you understand the barriers to the implemented cleaner production options which can be encountered on the work-floor?</td>
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<td>6. Have you taken measured to facilitate the implementation of these options, such as workshops, meetings etc.</td>
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<tr>
<td>7. Have you documented feasible options which are selection for Implementation?</td>
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<td>8. Have you documented non-feasible options?</td>
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<td>9. Have you adjusted planning and the time schedule for cleaner production assessment?</td>
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<td>10. Have you informed the management and employees about the progress of cleaner production assessment?</td>
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<tr>
<td>11. Have you prepared ‘before –and– after’ sheets for the implementation phase?</td>
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<tr>
<td>12. Based on the expected ‘before-and –after’ situation have you calculated the expected payback period?</td>
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</tbody>
</table>
### Technical Evaluation
Cleaner Production Option: ________________________________

<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
<th>NOT SURE</th>
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<tbody>
<tr>
<td>1. Have you determined whether other industries already have experience with this?</td>
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<td></td>
<td></td>
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<tr>
<td>2. Will this option maintain product quality?</td>
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<tr>
<td>3. Will this option adversely affect production?</td>
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<td>4. Will this option require additional staff?</td>
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<tr>
<td>5. Will workers be able to run the process with the implemented option?</td>
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<tr>
<td>6. Is extra training of the workers required?</td>
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<tr>
<td>7. Are you certain that this option will create less waste?</td>
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<tr>
<td>8. Are you certain that this option will not simply shift waste problems from one medium into the other [e.g. from solid waste to air emissions]?</td>
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<td>9. Is your plant layout and design capable of incorporating this option?</td>
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<td>10. Will the vendor guarantee this option?</td>
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<tr>
<td>11. Have you determined that this option will improve or maintain workers safety and health?</td>
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<tr>
<td>12. Does this option reduce wastes at their source?</td>
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<tr>
<td>13. Are materials and parts readily available?</td>
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<tr>
<td>14. Can this option be easily serviced?</td>
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<tr>
<td>15. Does this option promote recycling?</td>
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</tbody>
</table>

### Economic Evaluation
Cleaner Production Option: ________________________________

<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
<th>NOT SURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does this option reduce raw material costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Does this option reduce utilities costs?</td>
<td></td>
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<tr>
<td>3. Does this option reduce material and material waste storage costs?</td>
<td></td>
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<tr>
<td>4. Does this option reduce regulatory compliance costs?</td>
<td></td>
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<tr>
<td>5. Will this option reduce the costs associated with workers injury or illness?</td>
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<tr>
<td>6. Will this option reduce your insurance premiums?</td>
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<td></td>
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<tr>
<td>7. Will this option reduce your disposal costs?</td>
<td></td>
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<tr>
<td>8. Does this option have an acceptable payback period?</td>
<td></td>
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<tr>
<td>9. Is this option within your price range [Consider both capital and ongoing operation]?</td>
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</tbody>
</table>
### Environmental Evaluation

Cleaner Production option:

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
<th>NOT</th>
<th>SURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does this option reduce the toxicity and volume of your solid waste and sludge?</td>
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<td></td>
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<tr>
<td>2. Does this reduce the toxicity and volume of your waste water?</td>
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<tr>
<td>3. Does this reduce the toxicity and volume of your gaseous emission?</td>
<td></td>
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<td></td>
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<tr>
<td>4. Does this option improve the health and safety condition at the workplace?</td>
<td></td>
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</tr>
<tr>
<td>5. Does this option reduce the use of raw materials [per product]?</td>
<td></td>
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<tr>
<td>6. Does this option reduce the use of auxiliaries [per product]?</td>
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<tr>
<td>7. Does this option reduce energy consumption [per product]?</td>
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<tr>
<td>8. Does this option create new environmental impact?</td>
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<tr>
<td>9. Does the option increase the possibilities of recycling the waste streams?</td>
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<tr>
<td>10. Does this option increase the possibilities of recycling the product?</td>
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</table>

#### 4.1 STEP 12: PRELIMINARY EVALUATION

**Objective:** To determine at what level of detail each option should be evaluated and to make an inventory of what information is still needed to make this evaluation. The evaluation of selected options should base on technical, economic and environmental feasibility. Preliminary evaluation determines the level needed for technical, environmental and economical evaluation. Some options require procedural and employee changes. Complex options may need replacement of unit operation or may require extensive economical and technical evaluation. Each option should comprise of all information needed to conduct feasibility study.

#### 4.2 STEP 13: TECHNICAL EVALUATION

**Objective:** To determine the technical feasibility of selected cleaner production options.

**Explanation:** All major investments require a technical evaluation. The impact of the proposed measure on process, product, production rate and safety should be evaluated. Laboratory testing and trial runs of the options may be required when the option is significantly changing the present practices. It is important to include all employees and departments affected by the implementation of the options. The technical evaluation will determine whether the option will require staffing changes, additional operations, maintenance personnel or additional training of staff and personnel. Use the check list and work sheet for technical evaluation provided.

**For the technical evaluation attention should be given to the following points:**

- Description of the cleaner production option.
- Nature of the cleaner production option.
  - Equipment changes.
  - Change in production regulations.
  - Change in raw material and / or input materials.
- Nature of the change;
- General specification of equipment.
- Rough process flow chart.
- Material balance/ heat balance.
- Energy balance.
- Requisite change in procedures and production regulation.
- Change in raw material and auxiliaries.
- Necessary space needed with suggested location and branch.
- Prepare time schedule for constructing the installation and start-up phase

• Effect on production;
  - Possible effect on product quality
  - Effect on production capacity
  - Potential risk as regard to production output, production quality and production capacity.
  - Influence on production regulation.

• Effect on essential number of employees.
• Extra training required.
• Requisite licenses including safety, building permit, nuisance Act, air pollution Act, Chemical waste Act, surface water pollution Act and other environmental regulation
• Maintenance requirement for the modified installation.
• Essential extra storage space and transport facilities.
• Extra laboratory checks.

4.3 STEP 14: ECONOMIC EVALUATION

Objective: To evaluate the cost – effectiveness of cleaner production option.

Economic viability is the key parameter which determines whether or not an option will be implemented. It is advisable to first evaluate the options which are likely to be economically very attractive. This strengthens the interest and the commitment of the industry’s top management to adapt cleaner production. The economic evaluation is carried out using standard measures of profitability such as Payback period (PP), Net Present value (NPV) and internal Rate of Return (IRR). In performing the economic evaluation various costs and savings must be considered. The costs of a cleaner production option can be broken into investments and operating costs.

1. Collect data for calculating investments and operating costs
Total investment is the sum of the fixed capital costs for design, procurement and installation equipment, costs for working capital, licenses, training, start up and financing. In addition to the investments add operating costs and savings. First list all the operating costs associated with the current production process which are going to change due to the implementation of cleaner production options. Operating costs and savings associated with cleaner production options are;
• Reduction of waste management costs
• Savings on the cost of input materials including energy
• Insurance and liability savings
• Changes in costs associated with quality
• Change in facility costs
2. Profitability analysis/assessment

A project’s profitability is measured using the estimated net cash flow (cash incoming minus cash outflow) for each year of the project’s duration. Incremental operating costs can be used to compare the existing system with the new one. Incremental operating costs represent the difference between the estimated operating costs associated with the cleaner production options and the actual operating costs of the existing system without the option. Standard methods for measuring profitability are:

- Payback period (PP).
- Internal rate of return (IRR)
- Net present value (NPV) and
- Return of investment (ROI).

The formula for calculating the payback period before tax is as follows.

\[
\text{Payback period (years)} = \frac{\text{capital investment}}{\text{Annual extra cash flow}}
\]

Simple payback = Initial Investment
(in years) Year 1 cash flow

Or

\[
\text{Simple payback} = \frac{\text{Initial Investment}}{\text{Annual savings}}
\]

Payback method is recommended for quick assessment of profitability.

The internal rate of return (IRR) and the net present value (NPV) are techniques used for determining rent ability in which the cash flow are made constant. Allocation of capital funding for a project can depend on whether a project is able to generate sufficient positive cash flows after the payback period guarantee an acceptable return on investment. A project is feasible when the NPV is positive.

\[
\text{ROI (in %)} = \frac{\text{Year 1 cash flow}}{\text{Initial Investment}}
\]

If the project payback period is less than three (3) years, then the project is viewed as profitable.

If the return on investment (ROI) is 33%, then the project is viewed as profitable.

Note: The shorter the PP and the higher ROI, the better.
The internal rate of return (IRR) and the net present value (NPV) are techniques for determining rentability in which the cash flows are made constant. Allocation of capital funding for the project can depend on whether the project is able to generate sufficient positive cash flows after the payback period guarantee an acceptable return on investment. Both the NPV and the IRR take into account the time value of money by discounting the projected net cash flow to the present cash flow. NPV is the sum of the discounted cash flows over the lifetime of the project, using the industry’s cost of capital as the discount rate.

Therefore:-

\[
NPV_n = (PV_1 + PV_2 + \ldots + PV_n) - \text{Initial investment}
\]

Where:

- \(NPV_n\) = The net Present value of the project over \(n\) years.
- \(PV_1 \text{ through } PV_n\) = the cash flow from each project year (positive for cash inflows, negative for cash outflows).

If the project \(NPV\) is greater than zero, the project is considered to be profitable over that time period. If the project \(NPV\) is less than zero, the project is considered to be NOT profitable over that time period.

The internal rate of return (IRR) = the discount rate for which \(NPV = 0\), over the project lifetime (calculated in an iterative fashion).

\[
\text{Or } IRR = i_2 + \frac{NPV(\text{per})}{NPV(\text{pos}) + NPV(\text{neg})} (i_2 - i_1) \%
\]

Where:

- \(i_1\) = lower rate of return at \(NPV(\text{pos})\)
- \(i_2\) = higher rate of return at \(NPV(\text{neg})\)

3. Adjustment for risks and liability

Cleaner production can reduce the magnitude of environmental and safety risks for the industry. This can be reflected in the economic evaluation by easing the financial performance requirements of the project. For example, the acceptable payback period may be extended from one to two years or the required internal rate of return (IRR) may be lowered from 15 to 12 percent. Such adjustments indicate that certain elements which affect the risks for the industry cannot be included directly in the analysis. Environmental regulations that are imposed or likely to be imposed in future are important to be considered during the financial analysis. Fines, penalties due to non-compliance can result in a severe cut off in profitability of the industry. Liability issues such as contaminated soil can even lead to bankruptcy.

4.4 STEP 15: ENVIRONMENTAL EVALUATION

Objective: To determine the positive and negative impacts of the option for the Environment.

The environmental advantage is the reduction in the toxicity and quantity of waste and emissions.
Environmental evaluation must base on:
• Simple evaluation on the reduction in toxicity and quantity of waste and emissions and energy loss.
• In depth evaluation of the effect of composition of new inputs and outputs.
• Simple life cycle assessment (LCA).

Information needed to make a sound environmental evaluation of the relevant product, raw material or constituent part of the process is related to:
• Changes in amount and toxicity of waste and emissions throughout the product life cycle.
• Changes in energy consumption throughout the product life cycle.
• Shift in the environmental effects to other materials.
• Changes in degradability of the waste and emissions.
• The extent to which renewable raw materials are used.
• Changes in the reusability of waste streams.

In order to prioritize certain environmental effects over others, the national policy on the environmental and the government’s priorities for environmental protection should be studied. The greenhouse effect and ozone depletion are issues for almost all national environmental agenda.

4.5 STEP 16: SELECT OPTIONS

Objective: To document the results of the feasibility study and provide a list of cleaner production options which should be considered for implementation.

1. Document feasible and non-feasible options
At this stage the work done should be documented, including the work which has not lead to identification of a feasible option. In this way the project team can keep track of all considered cleaner production options. If the cleaner production assessment is conducted again, the new project team can review these options, and learn from the experience. Apart from becoming a reference document for seeking approvals for implementation, the report can also be used to obtain finances from external institutions.

The report should state the project costs, expected results and how the project will be carried out. Before the report is finalized it is essential to review the results with the relevant departments and to seek their support. The following issues should be addressed in this report;
• What changes in energy use and waste and emissions are expected?
• What intangible costs and benefits, such as reduced liability and improvement in the eyes of the employees and the community as a whole are expected?
• How much funding will be required and how it will be obtained?
• How could the before – and – after comparison be made?
• What is the industry’s anticipated competitiveness in the future?

2. Select feasible and non-feasible options
Economic constraints may prevail if there is no enough money to finance all options. Options can be ranked in order of their priority based on the NPV rate. The option with the highest NPV should have the highest priority for implementation. Then prioritize feasible options.
5.0 Phase V – Implementation

Objective: To implement the selected cleaner production options and to ensure ongoing cleaner production activities. At this stage, feasibility cleaner production options are implemented, monitored, and evaluated. Also, a plan for ongoing cleaner production activities is prepared.

It is important to get everyone involved in cleaner production implementation.

Worksheets for the implementation phase
The following worksheets are used for implementation of cleaner production:
- Checklist for the implementation phase.
- Cleaner production plan.

This worksheet can be used as a time schedule for the implementation of cleaner production options:
- Before – and – after comparison.
- Evaluate cleaner production Assessment.

Checklist for implementation phase
This checklist can be used to help organize the implementation phase. It can be used again at the end of this phase to evaluate whether all important issues of this phase have been addressed.

If the answer is positive, it implies that the report of other information is available and the information should be enclosing in the file of the cleaner production assessment.

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
<th>NOT SURE</th>
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<tbody>
<tr>
<td>1. Are all selected cleaner production options implemented?</td>
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<td>2. Are you regularly monitoring and evaluating the performance of the implemented Cleaner production?</td>
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<td>3. Have you made an actual ‘before-and – after’ comparison?</td>
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<td>4. Do you know the actual payback period of the implemented option?</td>
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<td>5. Have you evaluated the cleaner production assessment and the production goals?</td>
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<td>6. Have you developed a cleaner production plan for ongoing cleaner production activities?</td>
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<td>7. Are human and financial resource secured for ongoing cleaner production activities?</td>
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<td>8. Have you set a date for a follow –up cleaner production assessment?</td>
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<td>9. Have you filed all relevant information used during the cleaner production assessment?</td>
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<td>10. Have you prepared a report describing how your industry conducted the cleaner production assessment?</td>
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<td>11. Have you published the results of the cleaner production assessment?</td>
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<td>12. Have you informed management and employees about the progress of the cleaner production assessment?</td>
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5.1 STEP 17: PREPARE A CLEANER PRODUCTION PLAN

**Objective:** To develop an implementation plan for cleaner production options.

The plan should be drawn up, describing the duration of the project and finances and manpower needed.

1) **Evaluate cleaner production Assessment**
   The first four phases should reveal whether cleaner production assessment has been successful and deserves follow up. The cleaner production plan should describe how the follow up would take place. Options with no or low cost implemented during the pre-assessment, assessment and feasibility study phases should be evaluated by making ‘before- and –after comparisons to reveal if the provisions have been adequate and whether different monitoring procedures should be developed.

   The worksheet “evaluate cleaner production assessment” can be used for this evaluation.

2) **Arrange finances.**
   Finances for implementation of options obtained from the feasibility study should be arranged.

**Cleaner production plan**
**Process / Unit Operation / Activity________________________________________________________**

<table>
<thead>
<tr>
<th>Cleaner Production option</th>
<th>Responsibility</th>
<th>Implemented by [date]</th>
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</table>
### Before – and- after comparison

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<tr>
<th>Item</th>
<th>Price per Unit (P)</th>
<th>Rate before implementation [A]</th>
<th>Rate after implementation [B]</th>
<th>Incremental Benefits [B - A] *P</th>
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<td><strong>INP</strong></td>
<td><strong>Materials</strong></td>
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<td>Other;</td>
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<td><strong>OUP</strong></td>
<td><strong>Product</strong></td>
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<td><strong>By product</strong></td>
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<td>2.</td>
<td><strong>Solid Wastes</strong></td>
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<td><strong>Wastewater</strong></td>
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<td><strong>Gaseous emissions</strong></td>
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<td><strong>Total Economic Benefits</strong></td>
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### 5.2 STEP 18: IMPLEMENT CLEANER PRODUCTION OPTIONS

**Objective:** To implement the cleaner production options.

The cleaner production project includes the following:
- Planning.
- Designing.
- Procurement.
- Construction.
The project could fail if not backed by adequately trained employees. Training needs have been identified during the technical evaluation. Also people responsible for the implementation of the project should be informed about the job and the purpose of the option.

5.3 STEP 19: SUSTAIN CLEANER PRODUCTION ACTIVITIES

Objective: To sustain cleaner production activities within the industry and continuously look for ways to improve its environmental performance.

1. Importance of sustaining cleaner production activities
   Cleaner production should not be a short term affair. It should take root and prove genuinely successful in the industry. The project team should not lose momentum after implementing few cleaner production options. The first cleaner production assessment should provide the sort of learning experience needed to make the project team more effective and efficient at identifying, planning and carrying out cleaner production projects. The best way to sustain cleaner production activities is to introduce a cleaner production programme which encompasses all activities which are needed to gain enthusiasm and commitment for repeatedly conducted cleaner production assessments.

2. Design cleaner production programme
   The cleaner production programme is a comprehensive set of organizational, administrative and planning activities which aim at enhancing the cleaner production approach throughout the industry and the industry’s activities. Management commitment should continue and allow the project team devotes time to organize ongoing cleaner production activities. Ideas and other information concerning the next cleaner production programme should be gathered including the following components:
   • Assign a cleaner production coordinator.
   • Develop an action plan.
   • Evaluate and adjust the cleaner production programme.

Operation plan
   In the operations plan cleaner production contribute to improving efficiency in the use of raw materials, improving product design, maximizing of on-site reuse, segregating waste and increasing the quality of the product and the processes. This implies that preventive maintenance schedules should be designed and new equipment should regularly be checked on its environmental performance.

1. Purchasing procedures
   Changing purchasing procedures can control potential losses even before they enter the industry. The following purchasing procedures can be helpful in implementing cleaner production program more effectively:
   • Evaluate raw materials prior to purchase, in order to purchase only the least toxic ones.
   • Change to just-in-time purchasing to avoid spills or over-purchasing.
   • Ensure that new equipment is designed to reduce waste and emissions.
   • Channel purchases through one person to eliminate unnecessary purchases.
   • Obtain material safety data sheets (MSDSS) when purchasing hazardous materials.

These sheets contain chemical information that can help managers determine the nature of their wastes and emissions.
2. **Receiving procedures**
Changing receiving procedures can help to avoid the wrong product to be sent to you. This can be achieved by:-
- Designing a receiving area
- Train employees in proper handling methods to prevent property losses, injuries and costly waste disposal.
- Choose for quality suppliers
- Review purchase agreements including terms of receiving materials orders.
- Document agreement conditions to ensure that they are in accordance with specifications.

3. **Delivery procedures**
Changing delivery procedures is necessary in order to avoid receiving the wrong product. Agreement with your customers is needed. You need to arrange with your customer on the following:-
- Designate a receiving area
- Train material handlers.
- Ensure that the receiver inspects and signs the delivery agreement.
- Document the delivery agreements.

4. **Inventory procedures**
Inventory policy is an important part of the operation plan. Develop inventory procedures by taking into consideration on the following:-
- What are the risks of storing too much of a certain hazardous raw material?
- What is the shelf life of a material that you intend to purchase?
- Purchase appropriate sized containers to prevent losses, spills, evaporation etc.

Use the following worksheet to evaluate cleaner production assessment.

**Worksheet for cleaner assessment evaluation**

**Evaluate cleaner assessment.**

Date: ____________________________

Date of last evaluation: ____________________________

1. Have all cleaner production options been implemented? 
   If NO, list the options which have not yet been implemented and give reasons.
   -----YES----- NO---And

2. Does cleaner production remain a priority to the management and employees of the industry?
   -----YES-----NO---

3. Have responsibilities and tasks for cleaner production been divided?
   Describe; 
   -----YES-----NO---
4. Have your cleaner production option reduced costs through:
   - Reduction of raw material costs?  YES [Estimate]  NO
   - Saving in end-of-pipe equipment?  YES [Estimate]  NO
   - Reduced compliance costs?  YES [Estimate]  NO
   - Reduced disposal costs  YES [Estimate]  NO
   - Improved health and safety?  YES [Estimate]  NO
   - Other  YES [Estimate]  NO

5. Make the "before –and after comparison and fill in the attached form. How effective have the cleaner production option been [e.g. what measurable and what intangible benefits are identified]? Describe.
6.0 References

A practical guide to toxics uses reduction, benefitting from TUR at your workplace.


