

Cleaner Production for Small to Medium Sized Enterprises

Module 2: Environmental Quantities and Costs

2. Module 2: ENVIRONMENTAL QUANTITIES AND COSTS

At the end of this module you will:

- Further understand Cleaner Production
- Be able to prepare a process review for your company
- Identify the main environmental quantities and costs for your business (materials, waste, energy, water, other)

Contents

- 2.1 Cleaner Production: Overview
- 2.2 Process Review: Introduction
- 2.3 Environmental Costs and Benefits
 - 2.3.1 Direct external
 - 2.3.2 Indirect and internal
- 2.4 Stage 2: Environmental Quantities and Costs
 - 2.4.1 Task 2.1: Draft Process Flow Chart
 - 2.4.2 Task 2.2: Compile materials and waste quantities and costs
 - 2.4.3 Task 2.3: Compile energy and water quantities and costs

2.1. Cleaner Production

2.1.1 Strategy and Operational Definition

Cleaner Production is the continuous application of an integrated preventive environmental strategy to increase eco-efficiency and reduce risks to humans and the environment. In the past, environmental management has focussed on cleaning up pollution after it had been generated using so-called end-of-pipe techniques. Cleaner Production reverses this strategy by trying to prevent pollution being created in the first place.

Cleaner Production specifically focuses on:

- Processes: conserving raw materials and energy, eliminating toxic materials, and reducing the quantity and toxicity of all emissions and wastes before they leave the process
- Products: reducing the environmental impact along the life cycle of a product, from raw materials extraction to its ultimate disposal
- Services: incorporating environmental concerns into designing and delivering services

Cleaner Production is:

- A **continuous process** for achieving a progressive reduction in resource use and waste generation
- An **integrated approach** as it deals with more than just waste
- An **economical method** of reducing **ecological and environmental health risks**

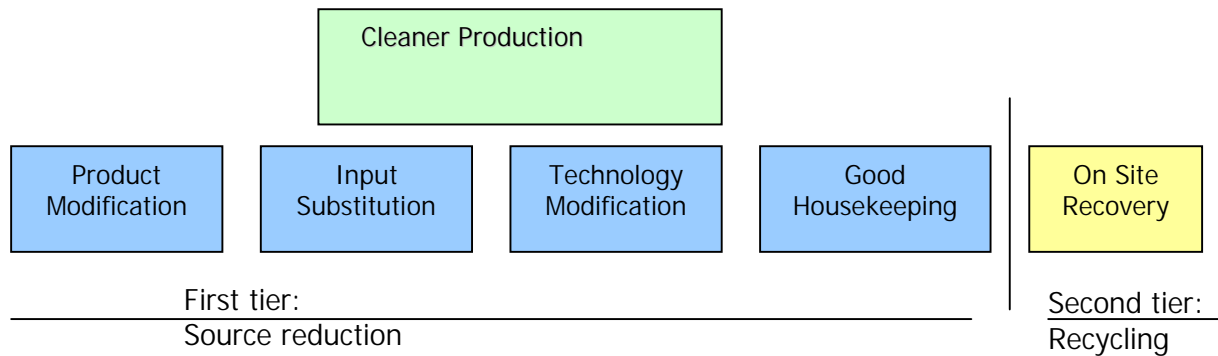


Figure 2.1 –Prevention Practices

Cleaner Production in industry is considered to encompass five general prevention practices:

- **Product modification:** changes in the product design and possibly the way it is used, in order to reduce environmental impacts of its production or of its use and disposal. This might involve changing the materials in the product, extending the life of the product, making it more easily repairable or changing the way it is manufactured. The ecodesign strategy wheel (Brezet et al, 1997¹)

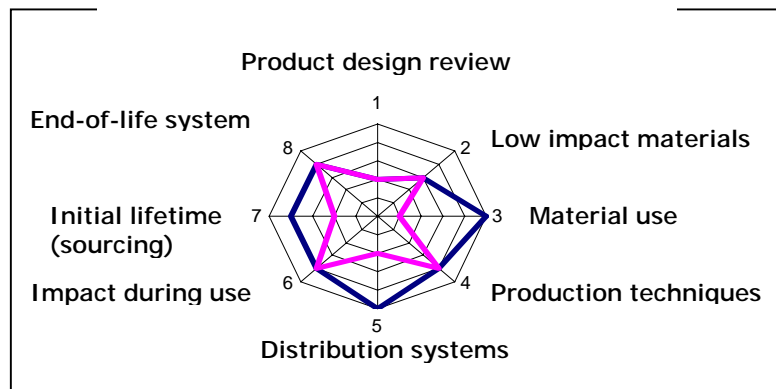


Figure 2.1 – Ecodesign strategy wheel

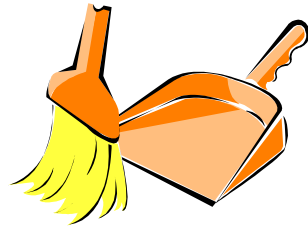
shows eight strategies that can reduce the environmental impacts of a product.

The strategy wheel provides a way of scoring a company's performance against each strategy dimension (increasing points away from the centre) and comparing against best practice for the industry.

- **Input substitution:** the use of alternative input materials, both product raw materials and auxiliaries such as coolants or detergents, to reduce the environmental impacts of the process or of the product use and disposal. New materials would be selected because they are:
 - Renewable
 - Less toxic/harmful
 - More appropriate for this application
 - Recycled or contains materials that have already been recycled
 - Recyclable or contains recyclable materials
- **Technology modifications:** changes in the production facilities to reduce environmental impacts of the production processes. A huge variety of technology modifications can be thought of, from as simple as efficient spray nozzles, better monitoring and control devices to completely new process technologies.

¹ "Ecodesign: A promising approach to sustainable production and consumption", UNEP, 1997

- **Good housekeeping:** changes in operating and maintenance procedures, and management and information systems, to eliminate or reduce wastes and emissions.



Typical examples:

- Spill and leak prevention
- Better inventory management
- Better production planning
- Better operating and maintenance practices

- **Recycling and recovery:** the use of the waste stream within the facility in which it is generated. This may involve simply reuse of the material as is, or it may require some reprocessing before re-use. Opportunities include heat recovery, process and cooling water recycling and recovery of input, intermediate and final products.

2.2 Process Review: Introduction

In order to generate Cleaner Production options it is necessary to have a systematic framework. One such framework is the Option Generation Model. The model consists of three steps:

Step 1. Source quantities/inventory: Where are materials, energy and water used and wastes and emissions – and costs- generated?

Step 2. Cause diagnosis: Are materials, energy and water used inefficiently? If so why, and why are materials wastes and emissions generated?

Step 3. Option generation: How can materials, energy and water be used more efficiently and wastes and emissions avoided?

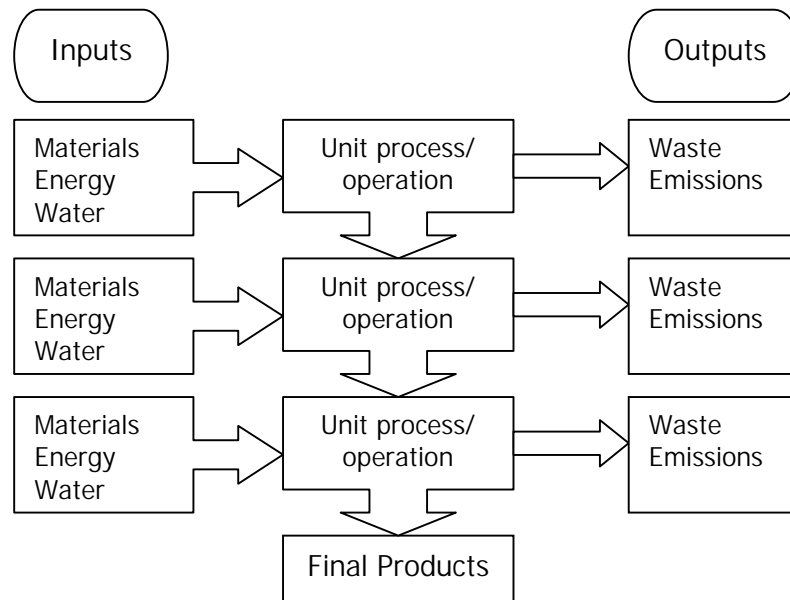
What would be the costs and savings or other business benefits for the option?

We introduce Step 1 here while Steps 2 and 3 are covered in Modules 3 and 4 along with further review of quantities where possible. In considering costs, however, you may already be aware of the priority items, sources and options.

Before you think about Cleaner Production options you need to have a full understanding of what materials and resources you are using to produce your products and services. You also need to know what wastes and emissions result from your processes.

The best way to identify where materials are used and converted to useful products or waste, is to draw up a process flow chart. The process flow diagram should show each individual step within your company's operation. All of the inputs and outputs for each step should be shown. It is important that this includes utilities such as energy and water. Consider support activities, such as transport, as well as main business processes operations, where support activities' impacts and costs are significant

Figure 2.2 - Process Flow Diagram



2.3 Environmental costs and benefits

To fully appreciate the influence environmental impacts have on your business you need to understand the associated costs. These costs provide a baseline for potential savings.



In this program you may wish to concentrate initially on your direct external materials, waste, energy and water costs, as they are likely to be most readily available and represent a significant part of your total environmental costs and of the scope for savings and other benefits. You should also be able to obtain at least summary information on quantities and costs.

Indirect environmental costs and benefits may be relevant and possibly more significant to your company. Indirect costs may be more difficult to obtain or estimate but it may be important to do so. Where these may be significant consider them in identifying priorities for improvement and evaluating options in Modules 3, 4, and 5.

2.3.1 Direct external costs and benefits

Direct external costs are any expenses paid to third parties for the supply of products and services directly related to a specific environmental aspect such as waste disposal. The following example and table can be used as a guide to calculating these costs.

Direct External Costs			
Input/output	Contractor/ supplier	Cost Items	Annual Cost
1. Painting materials	Acme Paint Suppliers	<ul style="list-style-type: none"> • Paint supply • Thinners • Filters 	\$ \$ \$
2. Waste: General rubbish	City of XX	<ul style="list-style-type: none"> • Container hire • Pick up charge 	\$ \$
3. Waste: Spray cabin wastes (filters, leftovers)	Waste disposal company	<ul style="list-style-type: none"> • Lease of filters • Service fee • Disposal fee 	\$ \$ \$
4. Waste water	Water Corporation	<ul style="list-style-type: none"> • Suspended Solids charge • BOD Charge • Volume charge • Sampling costs 	\$ \$ \$ \$
5. Electricity	Western Power		\$
6. Gas	Alinta Gas		\$
7. Water	Water Corporation		\$
		Total	\$

Information on current quantities and costs is likely to be available from bills and production or accounting records. Worksheets 2.2 to 2.4 provide tables for you to write summarise and prioritise the main cost items.

Materials and waste

Direct external materials costs are the costs of materials inputs to the business, these being sub-divided into production materials (used directly in the product, including packaging materials), and non-production materials used in ancillary or supporting functions. There will clearly be a financial incentive, providing quality and other requirements are met, for using materials more efficiently if possible, in order to use less and achieve savings in direct materials purchase costs.

The direct external costs of waste are the costs paid to waste contractors for waste disposal and container hire less any amounts received for recycled materials.

Direct external waste costs may include licence charges, based on volume and pollution load, for discharges to sewer, or costs of removing liquid effluent.

When compiling cost data, consider whether the figures for the latest year are representative, taking into account production volume, seasonality, weather conditions and other factors. Figures should be adjusted or normalised if possible ie convert to quantity per unit of production. The baseline figure should allow any improvements to be measured or estimated.

Energy and water costs

Direct external energy costs are the costs or payments for electricity, gas, oil, coal, fuel or other forms of energy, including compressed air.

Water costs are the costs of supply of potable water and any abstraction charges for bore water. Again, figures should be related, adjusted and normalised where appropriate to provide a baseline for improvement.

2.3.2 Indirect and internal costs and benefits

Besides direct external costs there are three other types of environmental costs to business which may be significant and which should be considered for savings benefits:

Direct Internal Costs

Direct internal costs are any expenses incurred within the business directly resulting from inefficiency in materials, energy or water use (ie the value of lost material), or the costs of managing environmental aspects such as on-site treatment of wastes.

The cost of waste (or an emission) is not simply the disposal cost, or even the cost of the lost material, but the value of all the materials labour and other inputs that have gone into producing the waste. The total cost, then, consists of the initial purchase cost of the materials and the costs associated with any processing of the materials that occurs prior to it becoming "waste" (this might include transport, storage, and heating).

For example, for a panel beater to dispose of waste paint it costs \$10/L. However, this is not the total cost of the waste, because it costs the panel beater \$20/L to purchase the paint. Therefore, the cost of this waste material is \$30/L. If the paint has been heated or has been mixed with another substance before becoming waste, the cost of the energy used to heat it, or the purchase cost of the other material should also be added to the total cost of the paint waste.

Costs may include not only the costs of normal wastes intentionally produced as a result of operations, but unintentional wastes from leaks or spills or equipment/plant left running unnecessarily.

The following table illustrates calculation of the direct internal costs of waste.

Direct Internal Costs				
Part A. Value Loss with Waste Streams				
Waste Stream	Valuable Component	Annual Volume	Unit Price	Annual Costs
1. General rubbish	• Metal off-cuts	tpa	\$/t	\$
2. Spray cabin waste	• Wasted paint	tpa	\$/t	\$
	• Used solvent	tpa	\$/t	\$
3. ...				\$
			Total	\$
Part B. Expenses for Environmental Activities Conducted by Own Staff				
On Site Environmental Activities	Personnel Costs	Material Costs		Annual Costs
1. Waste collection	xx hours/yr @ \$yy/hour	<ul style="list-style-type: none"> • Floor space for containers • Broom/wheelbarrow • Plastic Bags 		\$ \$ \$
2. Operation of Oil Separator	Maintenance for xx hours/yr @ \$yy/hour	<ul style="list-style-type: none"> • Depreciation of equipment • Chemicals used • Spare parts 		\$ \$ \$
3. ...				
		Total		\$

Indirect External Costs

Indirect external costs are any expenses paid to third parties for delivering products and services that strengthen the company's capability to manage its environmental aspects and risks such as license fees. The following table illustrates the calculation of various environmental costs.

Indirect External Costs		
Categories	Items	Annual Costs
1. Compliance costs	<ul style="list-style-type: none"> • Licensing fee • Document/report preparation • Fines and penalties • Costs of remediation or clean up 	\$ \$
2. Environmental Management System Costs	<ul style="list-style-type: none"> • External audits • Certification 	\$ \$
3. Environmental Risk Management Costs	<ul style="list-style-type: none"> • Insurance fees • Finance costs 	\$ \$
4. Environmental Communication	<ul style="list-style-type: none"> • Environmental report preparation • Publication and distribution costs • Site tours/hospitality 	\$ \$ \$
	Total	\$

Indirect Internal Costs

Indirect internal costs are any expenses incurred within the business for having the capability to manage environmental aspects and risks such as training of employees. The following table can be used as a guide to calculating these waste costs.

Indirect Internal Costs				
Activity	Component	Personnel Costs	Material Costs	Annual Costs
1. Environmental Management System	• Policy preparation and planning	\$	\$	\$
	• Document control	\$	\$	\$
	• Training	\$	\$	\$
	• Internal audits	\$	\$	\$
2. Others				\$
			Total	\$

Some rough rules of thumb about the composition of the total waste costs are:

- Direct, external costs are often 10-25% of total waste costs
- Direct, internal costs are often 50-70% of total waste costs
- Indirect, internal costs can be difficult to determine as they tend to be fairly intangible



Example: The poultry processing plant might identify the following costs:

	External Costs	Internal Costs
Direct Costs	<ul style="list-style-type: none"> • Solid waste disposal costs • Sewer discharge fees • Monitoring of BOD in waste water to sewer 	<ul style="list-style-type: none"> • Waste handling and storage • On-site treatment of waste water • Loss of valuable by-products
Indirect costs	<ul style="list-style-type: none"> • Licensing fees to the DEP, Water Corporation etc • Insurance Premiums for risk of environmental accidents • Interest payments on capital loans for treatment plant 	<ul style="list-style-type: none"> • Environment related training • Maintenance of the environmental management system

Other costs and benefits

Other costs and benefits may result from Cleaner production and Environmental management, some of which may be intangible or longer term

Costs might include:

- The contingency costs of production inefficiencies eg lost production when dealing with waste, clean up, accidents etc.
- Loss in value of the site or premises, product or equipment as a result of contamination.
- Costs to the business of planning or licensing delays as a result of inadequate performance.
- Loss of business from customers requiring better standards of environmental performance.
- High staff turnover or absenteeism if working conditions are poor

Benefits could include avoiding such costs or enhancing staff morale, business productivity and value.

2.4 Stage 2: Environmental Quantities and Costs

Returning to the Cleaner production Procedure we will now review the tasks for Stage 2:

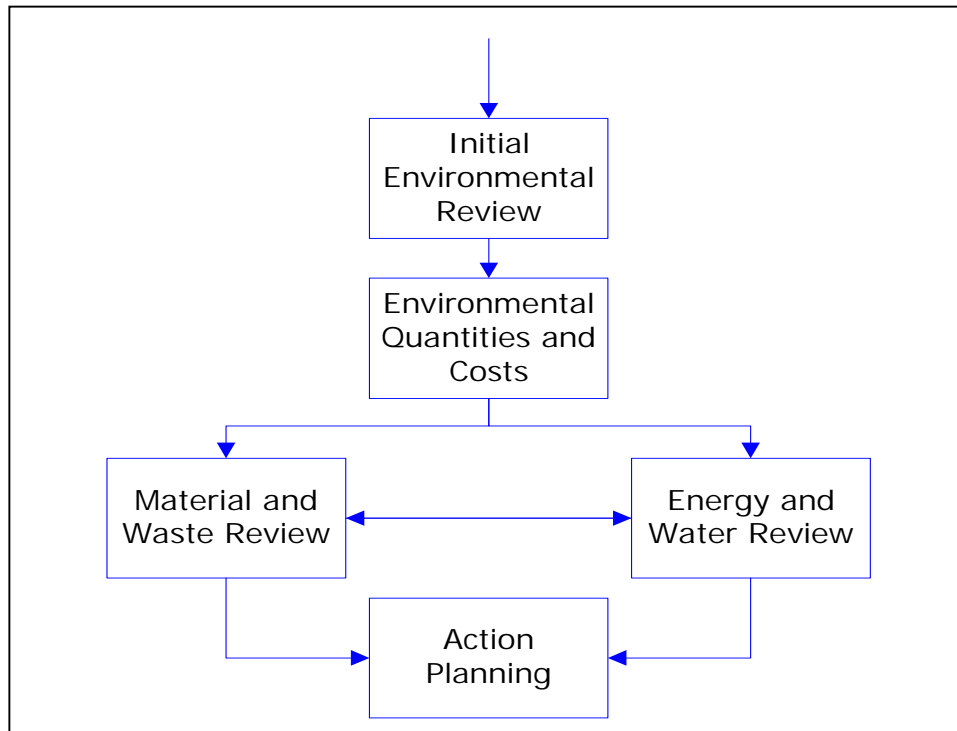


Figure 2.3: The five stages in the Cleaner Production procedure

Data on environmental quantities and costs will become the basis for all your Cleaner Production activities.

Stage 2: Environmental quantities and costs

Task 2.1: Draft process flow chart

Task 2.2: Compile materials and waste quantities and costs

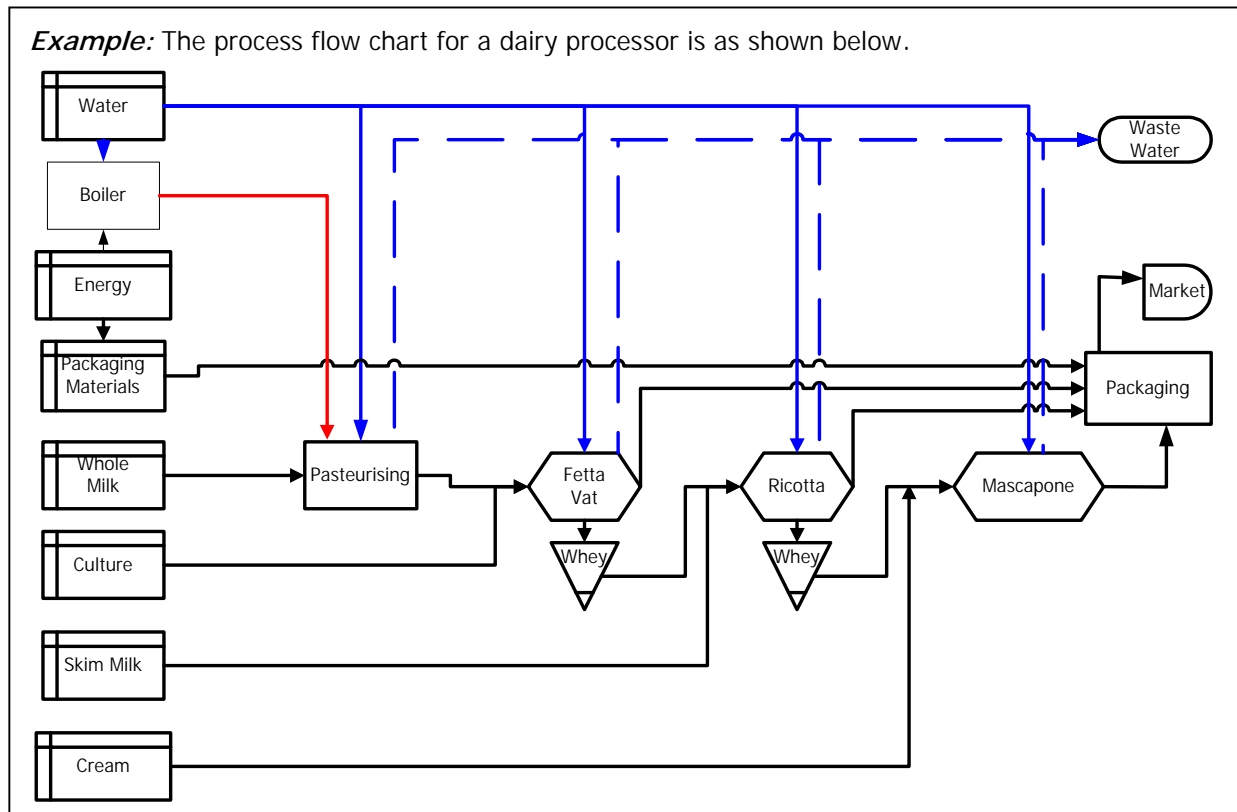
Task 2.3: Compile energy and water quantities and costs

2.4.1 Task 2.1: Draft Process Flow Chart

Drafting a process flow chart (Worksheet 2.1) is important for gaining a clear understanding of the steps involved in a process. It also shows which inputs and outputs relate to each part of the process. To prepare a process flow chart, you need to:

1. Identify all unit operations
2. Link unit operations and material flows

3. Match all inputs and outputs



2.4.2 Task 2.2: Materials and waste quantities and costs

Once you have prepared the flow chart, you can produce a table of materials quantities and costs and one for wastes (Worksheets 2.2 and 2.3). All of the inputs should have been shown on your flow chart. There are generally two types of materials inputs to any process.

1. Product raw materials (product components and ingredients)
2. Process auxiliaries or non-production materials (cleaners, oils, catalysts, coolants etc)

Example: The dairy processor has the following materials inputs and wastes.

<p>Product:</p> <ul style="list-style-type: none"> ➤ Whole milk ➤ Skim milk ➤ Cream 	<p>Process auxiliaries:</p> <ul style="list-style-type: none"> ➤ Cleaning chemicals ➤ Packaging materials ➤ Culture
<p>Waste</p> <ul style="list-style-type: none"> ➤ Packaging ➤ Office waste 	<p>Discharges</p> <ul style="list-style-type: none"> ➤ Whey ➤ Cleaning chemical ➤ Cleaning water <p>Air Emissions:</p> <ul style="list-style-type: none"> ➤ CO₂ / NO_x ➤ Odour

In addition to the list of materials inputs, your list

should show the quantity purchased each year and the associated annual cost for each. Your list of wastes should include all wastes in each of the following categories: recyclables, controlled wastes, general rubbish etc, and the costs of treatment or disposal.

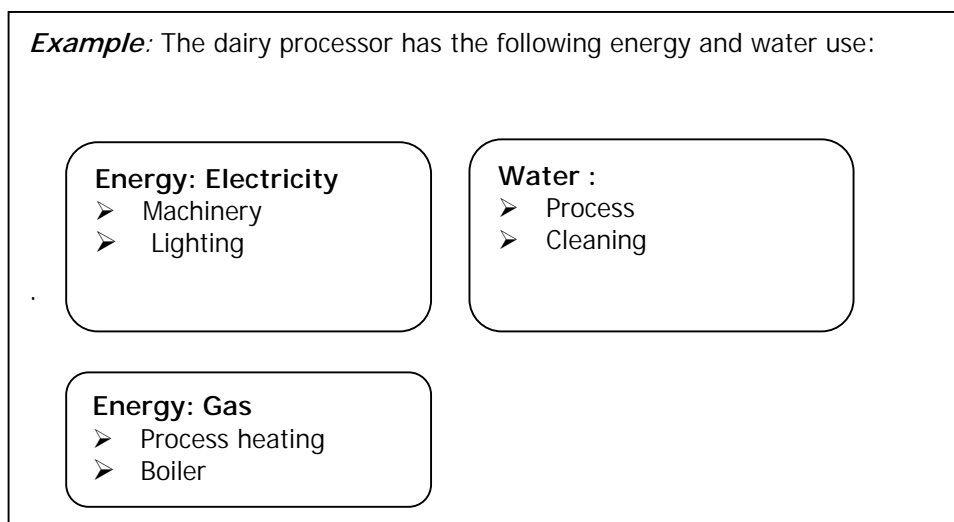
Also reference other wastes where there is a cost implication – eg

- Materials or production value in wastes.
- Discharges to sewer or stormwater: Costs may include discharge consents, costs of prevention, potential fines
- Air emissions (combustion, process, and transport emissions): Costs of abatement
- Waste heat: Costs of heat losses

2.4.3 Task 2.3: Energy and water quantities and costs

Taking electricity, gas and other energy uses in turn consider all of the production and non-production uses and list them. Estimate quantities for the main specific uses where possible using total quantities and apportionment according to equipment rating or other information (Worksheet 2.4).

Do the same for water (Worksheet 2.5), considering scheme and bore water separately. Where total figures are not available make an estimate.



Worksheets

Complete the worksheets as described above
Identify cost saving priorities (Worksheet 2.6).

Results

At completion of this Stage you should have the following information which can be used to establish focal areas for Cleaner Production:

1. Quantification of use of environmentally relevant resources (materials, energy and water) and waste
2. Estimates or data on costs.

Conclusion

- Cleaner Production is about prevention rather than a cure. It calls for systematic review of production processes, quantities and costs.

