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ENVIRONMENTAL INITIATIVES IN INDIGENOUS INDUSTRY

Best Practice Guide NO. BPGCS004

PROCESS LOSS REDUCTION

This is the second document on loss reduction. The *Resource Loss Mapping* (BPGCS003) document is recommended for a company initially setting out on establishing where losses are occurring. This document here addresses in more detail how to relate losses to the manufacturing process.

Introduction:

"Loss reduction" is the term used to describe the process of systematically reducing losses at source. It covers:

- raw material and ingredient use;
- product loss;
- water consumption and effluent generation;
- paper and packaging;
- factory and office consumables;
- energy consumption;
- all other solid and liquid wastes;
- gaseous emissions;
- wasted effort.

Companies that take steps to reduce the amount of losses generated, not only save the costs of managing these, but also make much greater savings on the cost of inputs to the production process. Reducing losses is therefore essential to maintaining business competitiveness. It also makes good business sense to reduce waste disposal costs by looking at ways of producing less waste.

Material Flows:

First of all, it is necessary to understand the company's processes and identify all the materials that could be considered for loss reduction. Figure 1 shows a generalised process model for the flow of materials through a simple manufacturing facility. A similar model could be applied to a commercial organisation. Inputs are purchased raw materials and all other materials necessary to perform the process. Outputs consist of products sold to the customer and losses to the environment.

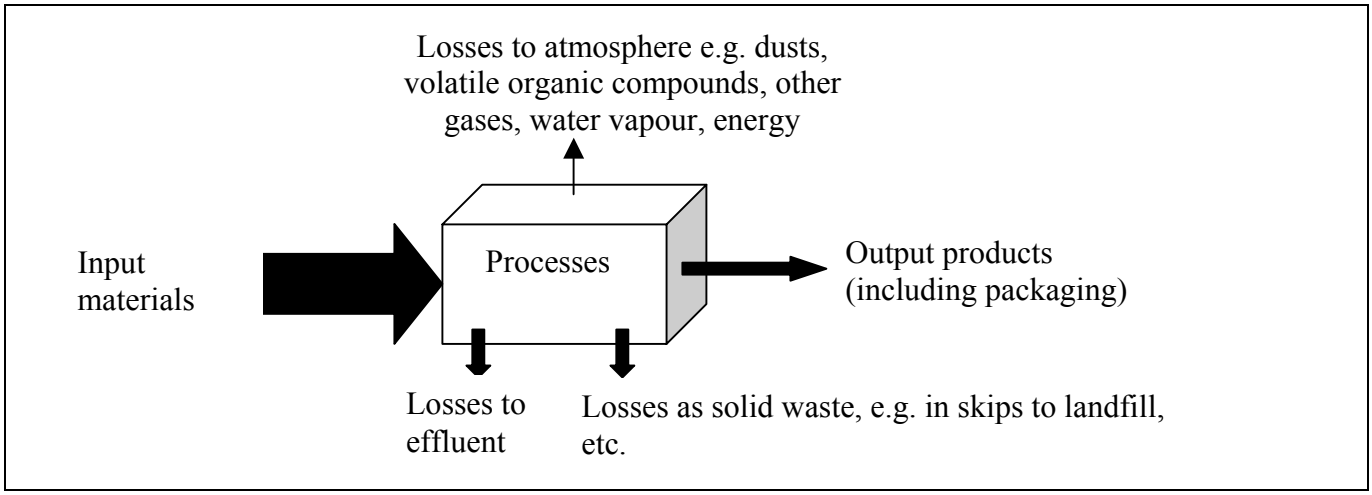


Figure 1. Generalised process model

Within a process, any reworking will contribute to the loss of time, utilities and resources. These too should be minimised. Figure 2 shows material flows through a manufacturing process. Materials are categorised as either inputs or outputs.

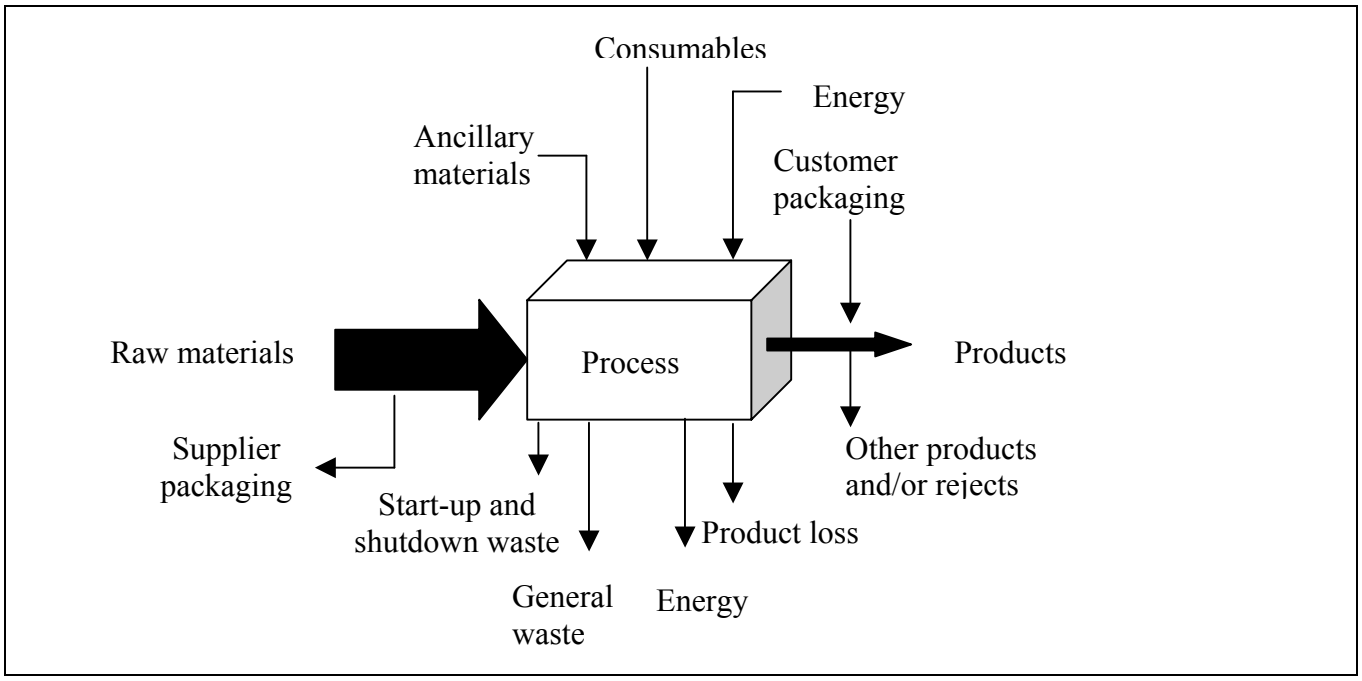


Figure 2. Material flows through a manufacturing process

Input materials:

There are several types of input materials (see below).

Type	Use
Raw materials	Materials that end up as part of the final product e.g. flour and eggs used in cake-making.
Ancillary materials	Materials that are essential to the manufacturing process, but which do not form part of the final product, e.g. washing-up liquid used for cleaning purposes.
Supplier packaging	Packaging material used in the delivery and storage of the raw and ancillary materials, e.g. cardboard boxes, drums, plastic bags, etc.
Consumables	The wide variety of items needed during the manufacturing process and which make it work, e.g. protective gloves, hand-cream, soap, overalls, rubber boots, etc.

Output materials:

Several categories of output materials should be considered (see below).

Type	Source
Product loss	Product which is made to the correct specification, but is lost before it reaches the customer, e.g. powder products spilt on the floor, liquid products washed to drain, etc.
Other-products	Produced by some processes as a consequence of the manufacturing sequence.
Rejects	Degraded or off-specification products that are produced but which fail quality control checks. They therefore cannot be sold as top quality product. Rejects may be saleable as 'seconds' or as 'sub-standard', but at a reduced price.
Supplier packaging	The packaging associated with deliveries.
Customer packaging	The packaging in which the finished goods are delivered. Such packaging may create a disposal problem for the customer.
Excess	Products that are made but which are superfluous to requirements, off-cuts and products that are given away.
Start-up and shutdown wastes	Waste generated during plant start-up and shutdown.
General waste	Consumables, leaks, spillage, materials used to mop up spillage, discarded protective clothing, cleaning materials, paper and other office waste, etc.

Review of current situation:

Several stages are required to gather all the data and information needed to identify the reduction opportunities and to determine potential savings.

Initial review:

This identifies those areas of the business producing the most losses, and which therefore require priority attention in a loss reduction programme. The initial review will also help to decide the programme boundaries. The aim is to determine the quantities of material used and the costs associated with different forms of losses.
The three main stages of an initial review are:

Stage 1: Draw a simple diagram with qualitative details of inputs and outputs.
Stage 2: Add quantitative details of inputs and outputs.
Stage 3: Identify the types of processes being carried out.

To carry out the review it will be necessary to put a team together. This team is most effective if it includes representatives from:

- engineering/site services, i.e. those responsible for the installation and maintenance of plant and equipment;
- production, i.e. those responsible for the day-to-day operation of converting raw materials into products;
- management, i.e. those responsible for production scheduling and corporate decision-making.

Sources of data:

Many sources of data may be available, including:

- management reports;
- production statistics;
- material use reports;
- bills of materials and other costings;
- other product and waste disposal records;
- effluent analysis for chemical oxygen demand and suspended solids content;
- customers and suppliers;
- Energy reports.

There may be insufficient data in some areas, so make a rough guess of the measurable value and evaluate the cost of improved data collection. Improved data gathering can then be instigated if the cost or need is justified.

Additional data gathering techniques may include:

- Using checklists, e.g.:
  - hours run;
  - number of components produced per machine;
  - reasons for product rejection on grounds of quality.
- Installing meters to measure water use in key areas of the plant. It is usually cheaper to meter water in rather than effluent out.
- Installing meters to measure energy consumption, i.e. gas, electricity, steam, etc.

Data Analysis:

Producing a mass balance of a process or site involves tracking materials through the process/site and identifying their destination and efficiency of use. The mass balance also enables unmeasured streams to be estimated and/or areas missed from the flow diagram to be identified.

Mass balance:

A mass balance presents the 'balance sheet' for material use. It is based on:

Input of material – Output of material = Change in inventory

A hypothetical mass balance is shown below:

Inputs to process (kg)		Outputs from process (kg)	
Raw material purchased	1000	Products sold	800
Decrease in raw material stocks	200	Increase in product stocks	300
		Poor quality product sold to scrap dealer	70
		Degraded product sent to landfill	20
		Estimated product loss to effluent (by difference)	10
Total	**1200**		**1200**

Yields:

Determining the route by which a lost yield leaves the process/site, and the stage at which it is lost, helps identify loss reduction opportunities.

Yields, which are generally sector-specific, are usually calculated in one of two ways. Both methods present the efficiency of use of material while making product, and both can be quoted for raw materials, other materials, or utilities.

Name	Raw material	Other material
Specific yield	Quantity of product produced per unit of raw material consumed, eg: - weight of chemical out/weight of chemical in; - tonnes produced/litre consumed; - m^3 produced/kg consumed.	Quantity of product produced per unit of material consumed. Units of material consumed per unit of product produced, eg: - gloves used/item produced; - kWh energy/tonne produced; - tins of paint/area painted.
Relative yield	Percentage of raw material converted to product, eg: - 85% conversion clay to bricks; - percentage attainment of theoretical yield.	

Assigning a value to lost yield helps to identify the scope for savings. A simple approach is to assign full product value for losses downstream of product formation, but only raw material value for upstream losses.

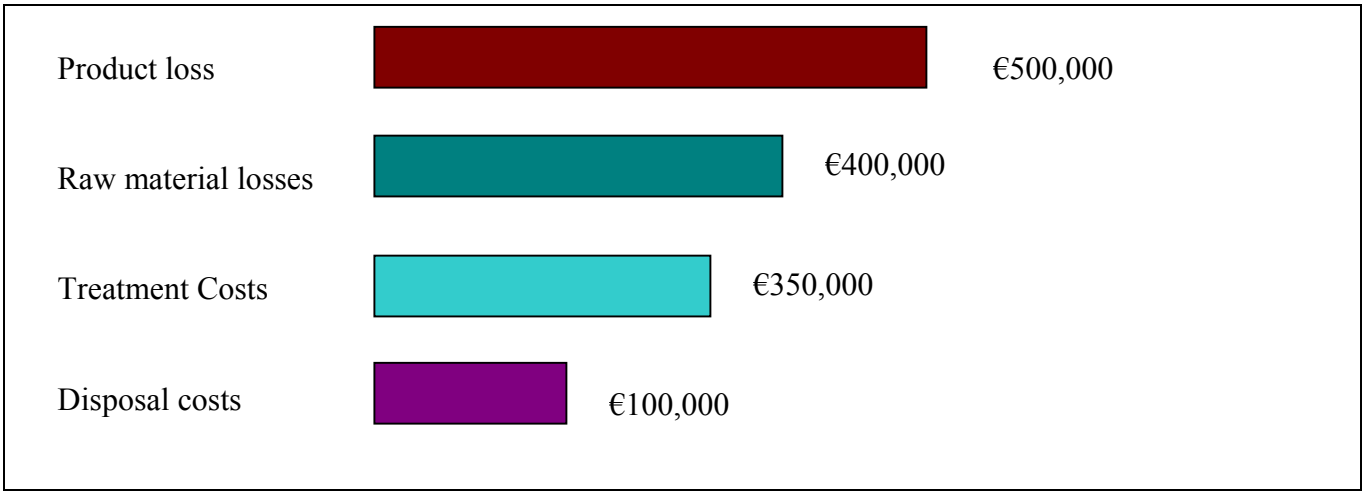
Scrap/rework analysis:

For a scrap/rework analysis, both the number of faulty pieces and the nature of the fault are recorded. The action to be taken for each type of faulty piece is also given. Presented below is an example from a painting process producing some sub-standard parts?

Input		Fault		Action	
Number of pieces painted	3400	No faults	3100	Passed	3100
		Scratched	50	Rework	50
		Underspray	20	Rework	20
		Dented	230	Rework	30
				Scrap	200
Total	**3400**		**3400**		**3400**

Cost of losses:

The final step in this stage of the loss reduction initiative is to collate the information in a way that shows the total cost of losses. This highlights the major areas that should be addressed in a loss reduction programme. A typical situation in which the costs of product loss dominate waste costs is shown below.



Prioritising areas for improvement:

The use of the data is to prioritise those areas of the business requiring attention. The following should be considered:

- the saving potential;
- the relative ease of achieving the saving, including the availability of human and financial resources;
- the need to generate results to maintain commitment;
- the time it will take to develop improvement opportunities;
- whether loss minimisation would fit in with any existing initiatives.

The approach taken by site management will depend on local conditions.

A number of tools and techniques, many of them graphical, can be used to help identify minimisation opportunities.

Data presentation:

The data should be presented in a simple, logical format for easy comprehension and to prompt further questions. The different forms of chart that might be used are presented below.

Format	Description
Pie chart	Relative data are shown in the form of a circular pie. This is a useful chart to use when the absolute total is less significant than the relative size of one portion to another.
Histogram	Takes the form of a bar chart that can be used to illustrate numerical values in a range of categories.
Pareto analysis	A form of histogram where the categories are ranked in order of size. Used to highlight the 'significant few'.
Sankey diagram	Horizontal bar chart showing the fate of input materials in proportion to the width of the bars. Extremely useful in showing recycle streams (rework, reprocessing, corrections, etc.) that are difficult to show on a pie chart.

Employee suggestion schemes:

These can prove a useful method of generating ideas for reducing losses:

- it is best if suggestions are sought for well-defined areas;
- it may be necessary to limit suggestions to no-cost and low-cost measures;
- feeding back results is essential for the scheme's continued success.

Generating loss reduction ideas:

A structured approach should be followed (see Figure 3) to ensure that the root cause of the loss is found and hence any loss is eliminated/minimised at source.

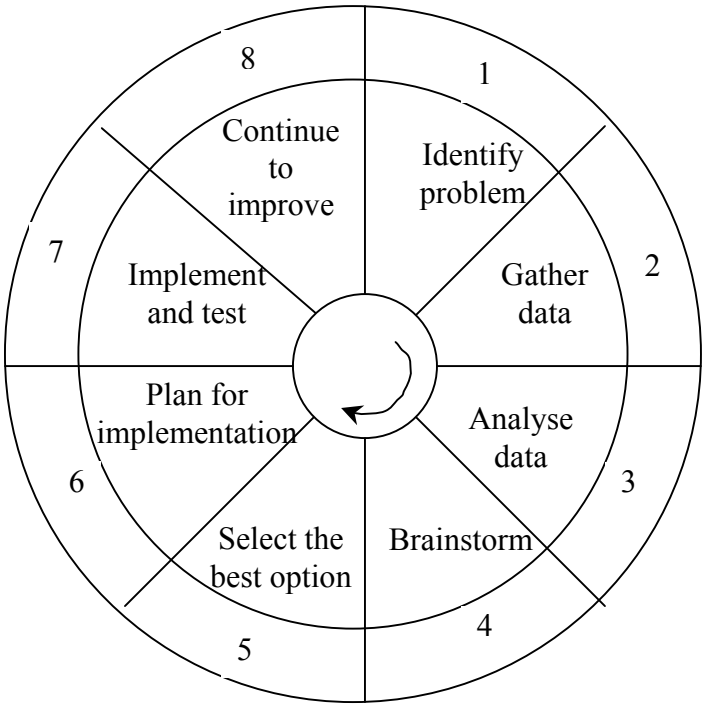


Figure 3. Structured problem solving

For each individual waste stream, the team should consider:

- Why is the waste formed? Is it a process characteristic or does it result from other known, or possibly unknown, procedures?
- When is the waste formed? Which stage of the manufacturing process leads to waste?
- Is the waste formed by a component essential to the process, e.g., intermediates, raw materials, etc or other materials and additives such as solvents, carriers or diluters, etc, which could be replaced?

With the answers to such questions, it is possible to identify the root cause. It can be useful to record the ideas in a structured form, e.g. a 'cause and effect' diagram (see Figure 4).

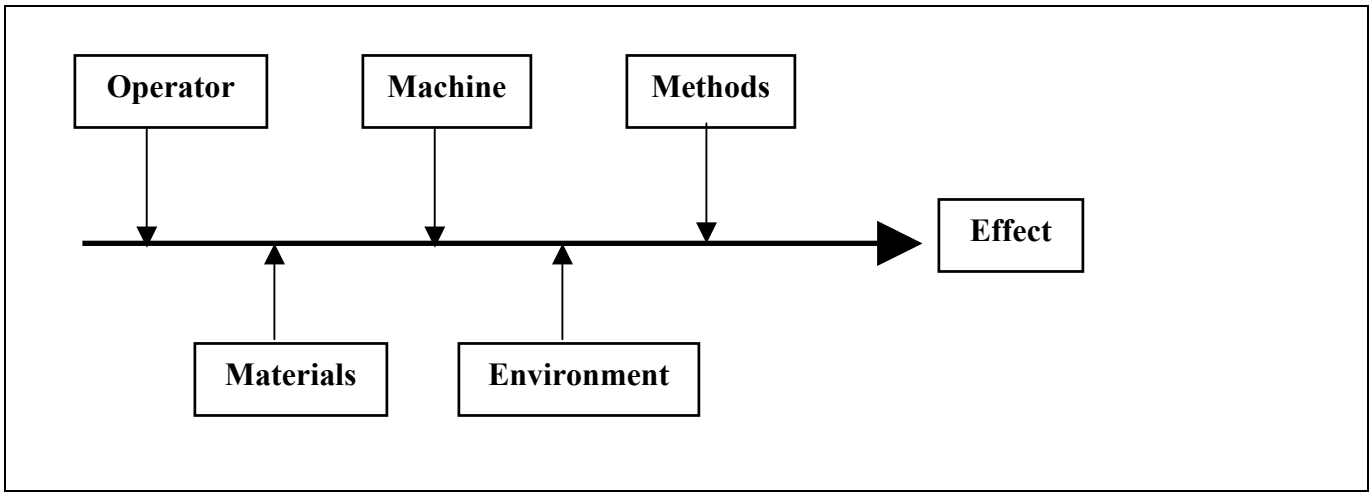


Figure 4. Cause and effect diagram

This type of diagram can illustrate how there may be a number of possible primary (root) causes generating an effect. If the primary causes for a particular loss is not known, then a good starting point is 'Operator-Machine-Materials-Methods-Environment'.

Screening loss reduction options:

Having identified several options for reducing losses arising from a particular stream, it is necessary to evaluate these options to determine the best option to implement. A number of techniques exist.

Simple rating mechanism:

This method of screening loss reduction options involves awarding points from 1 - 5 as follows:

- waste management hierarchy — 5 = reduction/elimination at source (best option); 1 = disposal (worst option)
- implementation potential — 5 = can be implemented immediately; 1 = not feasible
- type of option — 5 = good housekeeping; 1 = new technology
- cost of option — 5 = no cost; 1 = outside limits of budget

Example of the simple rating mechanism in use:

The following hypothetical example involves contaminated solvent that is currently sent off-site for incineration. The loss reduction options considered are:

(a) install distillation column and recover on-site;
(b) reduce solvent charge to process;
(c) find off-site users for contaminated solvent;
(d) recovery by specialist solvent company.

Points were awarded for each option in the four categories mentioned above. The points were then added together to produce a total score (see Table 1).

Option	A	B	C	D
Waste management hierarchy	4	5	4	3
Implementation potential	3	2	2	4
Type	1	4	4	4
Cost	1	4	3	2
Total	**9**	**15**	**13**	**13**

Table 1. Screening loss reduction options for a contaminated solvent waste stream

According to this analysis, the 'best' option is to reduce the solvent charge to the process (option B) and hence minimise the quantity of contaminated solvent produced. However, any process change would need to be validated, as indicated by this option's low rating for implementation potential. The next best options are recovery and off-site re-use.

Technical and economic feasibility analysis:

Screening identifies the best options for reducing losses. However, these options must be subjected to technical and economic feasibility analysis to prioritise them for implementation.

Technical feasibility is, of course, paramount. However, it is likely that, by this stage of the problem-solving process, this has already been assessed. Financial appraisal enables the technically feasible options to be prioritised.

Financial appraisal has four objectives:

- to determine which investments make the best use of the organisation's money;
- to ensure optimum benefits from each of these investments;
- to minimise risk to the enterprise;
- to provide a basis for the subsequent analysis of the performance of each investment.

This process produces a measure of the financial contribution each project would make to the business, identifies the risk and uncertainties in each project, and defines the expected costs and benefits. The decision-taker then uses the results to choose between projects. Other factors taken into account during financial appraisal are the cost-structure of the business and how each project relates to policies regarding capacity, quality, flexibility, product mix, etc.

Implementation:

When implementing any loss reduction initiative, it is important to prepare carefully and follow a structured plan. Having decided which reduction options to implement, it is important to:

- identify the forces for and against the proposed change;
- identify ways of overcoming any anticipated problems;
- develop a clear, concise plan of action and communicate this to all concerned with the proposed changes;
- ensure that adequate training has been provided in the operation of the 'new' process.

Before making any changes, it is important to set up a system to monitor their effectiveness once in place. This measurement system may well be the one constructed to aid data collection. The next steps are then to implement the system and monitor it to ensure that the desired outcome is achieved. Implement only one change at a time because this allows the effectiveness of each change to be accurately assessed.

Monitoring the benefits:

In any improvement process, it is essential to measure and evaluate the results of the implemented changes. This enables successes to be quantified, failures understood, and new targets to be set.

Performance measures may be needed at a number of levels, e.g.:

- plant, process, equipment, production line;
- site, factory, business unit or group;
- by material or product;
- by shift or team.

Regular reporting of results is essential to ensure ownership of the loss reduction programme at all levels of the organisation. Feedback needs to be in terms that are meaningful to its recipients. Some suggestions are given below.

Grade	Domain	Type of information
Employees	Plant, equipment, shop floor, shift or production line.	Simple financial savings relating to individual options for improvement. Total savings achieved in a given period. Number of opportunities generated and implemented.
Management	Process, material or product.	Process performance in terms of yields or production rate.
Board	Site, factory, business unit or group.	Financial measures for each period and for the whole loss reduction programme. Ongoing measurement and reporting at board level of the true cost of losses, i.e. not just disposal charges.

Maintaining momentum:

To avoid problems and ensure that the momentum of a successful loss reduction programme is maintained the management and measurement of the performance of the programme should be continuously revised.

Management:

1. The role of senior management is crucial to the success of a loss reduction programme. Employees on the shop floor can achieve results only if they are given time and resources to do so.

2. Not only must senior managers be committed to reducing losses, they must be seen to be committed. Otherwise real benefits will not be realised.

3. 'Fast Starts' are easily spotted, readily implemented opportunities to reduce losses. Implementing such projects early on and publicising the results will help to:
   - raise awareness of the loss reduction initiative within the company;
   - demonstrate that the initiative can produce results;
   - gain support from all levels of staff.

   However, it is important to distinguish 'Fast Starts' from 'Cherry Picking'. The latter term is used to describe immediate, apparently beneficial opportunities that may, however, jeopardise further improvements. For example, although on the face of it segregation of packaging for recycling may seem an obvious opportunity, it would be far more cost-effective and environmentally beneficial to look for ways of eliminating the packaging altogether, e.g. by making use of, a returnable packaging system involving partnership with suppliers.

4. Accountability
   Making plant/process/area managers accountable, not only for production but for loss generation and utility consumption, will help to focus their attention on reducing losses.

   Such a change may require new procedures for measuring daily/weekly production and consumption at a production unit level, rather than as 'goods out of the gate'.

5. Maintaining focus
   Loss reduction must fit in with other initiatives that a company may be undertaking, e.g.:
   - Total Quality Management (TQM) - continuous improvement, process and customer focused;
   - Business Process Re-engineering - concerned with end-to-end processes, customer focused;
   - Quality Management Systems, e.g. EN ISO 9001 - standardised operating procedures;
   - Environmental Management Systems, e.g. ISO 14001, the EC's Environmental Management and Audit Scheme (EMAS) - continual improvement, reduced environmental impact;
   - Investors In People - training, awareness.

   However, focus must be maintained, otherwise effort and resources can become too thinly spread.

Measurement:

Ongoing performance measures are essential.

Statistical process control (SPC):

All production processes are subject to a degree of variation due to:

- **Inherent causes**. These are unavoidable. They may be due to the nature of the process, the quality of raw materials, the type of machine, etc. A process that varies only because of inherent causes is said to be 'in control'.

- **Special causes**. These are due to specific changes from the norm, e.g. wrong material added, machine adjusted incorrectly, breakdown, etc. When a process varies due to special causes, it is said to be 'out of control'.

Statistical Process Control (SPC) applies statistical tests to the measurements from a process to determine whether the process is performing satisfactorily, i.e., whether it is 'in control' or 'out of control'. Identifying the causes for a process going 'out of control' will lead to improved control and reduced losses.

The main tools of SPC are control charts. Control charts provide a visual means of determining when the process is 'in control' and when it is 'out of control'. Such charts can be used, and understood, by people with little or no knowledge of statistics. It is best to position these close to the plant or equipment generating the measurements.

Monitoring to manage:

Monitoring to Manage is a management approach to controlling and minimising energy, water, material and waste costs. It depends on placing accountability for the use of materials and utilities on the individuals using them. This approach helps to overcome the problems of responsibility. However, these individuals should be provided with appropriate management information so that they can control and reduce losses.
The following steps are required to establish such a programme:

- sub-meters to monitor energy, water and material consumption to identifiable areas or pieces of plant. These areas/plant are known as Account Centres (ACs).
- Determine the performance of each AC by relating material and utility use or waste produced to a measure of output.
- Establish a regular (weekly or monthly) reporting system that gives a performance measure for each AC and identifies variation in terms of financial gain or loss. In this respect, Monitoring to Manage is a form of SPC.
- Set up departmental teams that hold regular meetings to discuss ways of improving performance.
- Create a mechanism for providing regular feedback to help foster a more 'efficient' culture.