Measuring to Manage Resources and Wastes

An introduction

ZERO WASTE SCOTLAND

Zero Waste Scotland works with businesses, communities, individuals and local authorities to help them reduce waste, recycle more and use resources sustainably.

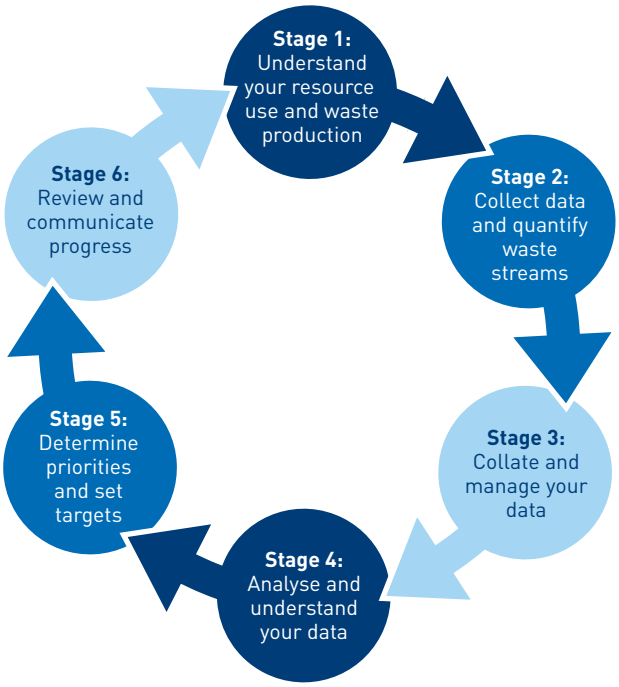
For more information about Zero Waste Scotland's services and other publications that will help you, please visit the website (www.zerowastescotland.org.uk) or contact the free Helpline on 0808 100 2040.

Summary

Scotland's Zero Waste Plan and other legislation require businesses and public sector bodies to change the way they operate. Therefore, Zero Waste Scotland has produced this guide to help environment managers; health, safety and environment managers; finance departments; or members of other management teams to use measurement and benchmarking techniques as a means of understanding their business operations to allow them to respond to these changes.

Measuring and benchmarking should be one of the first steps a business takes to improve its environmental performance. Without a good understanding of how, where and when resources are used, it will not be possible to manage them in an efficient manner. Take the time to measure before changing anything. Measuring and benchmarking provide the foundation for improving your environmental performance and setting up a management system, whether it is an environmental management system or carbon management plan.

This guide will provide you with the tools to implement the six key stages (see below) necessary to measure and benchmark your business's environmental performance effectively, and use this information to ultimately determine priorities and to inform decision-making. Following these established best practice methods and techniques will allow your business to minimise the costs associated with a monitoring and benchmarking programme, and allow you to understand your resource use. This guide will also enable you to make informed decisions on how to minimise waste production, thus helping Scotland move towards becoming a Zero Waste economy.



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1 Introduction

This guide will provide you with the tools to implement the six key stages necessary to measure and benchmark your business's environmental performance effectively

This Guide has been produced by Zero Waste Scotland as a practical resource for Scottish businesses. It is designed to help you manage your resources more effectively, improve your data management systems, better understand the wastes that your business produces, and provide you with a methodology to help quantify waste and monitor progress in reducing it.

1.1 Who is this guide for?

The guide is applicable to businesses of all sizes and from all sectors of industry. It will help anyone who wants to obtain a better understanding of their business resource use (e.g. environment managers; health, safety and environment managers; finance departments; members of other management teams; or anyone who has been given the responsibility to gather and analyse data).

1.2 Aim of this guide

Measurement and benchmarking provide the foundation for improving your environmental performance and setting up your management system, whether it is an environmental management system or carbon management plan.

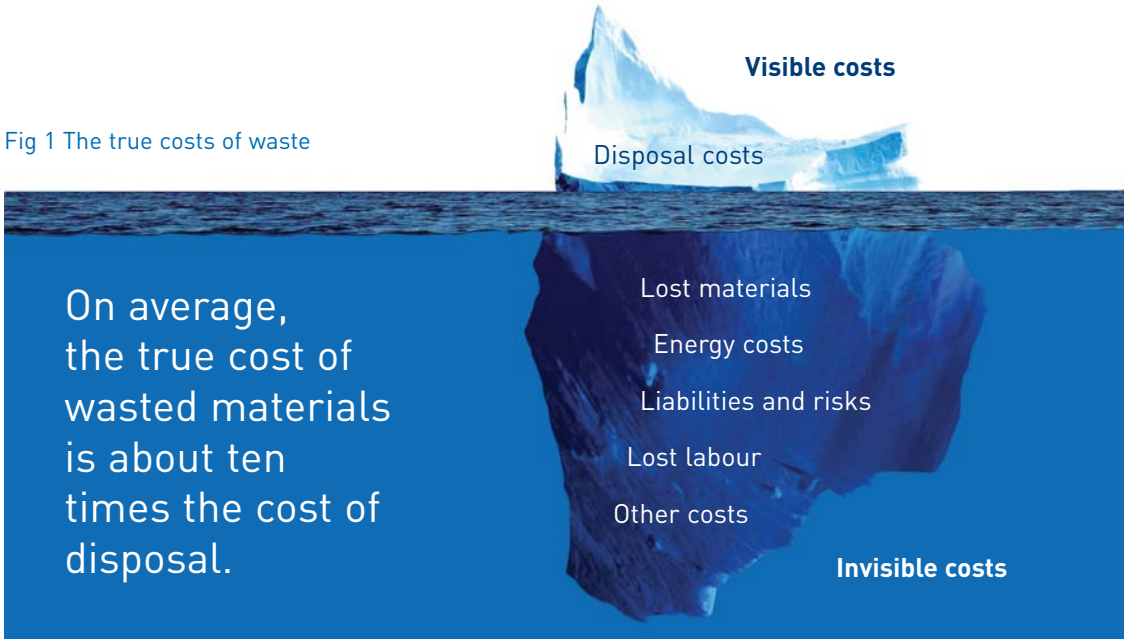
This guide will provide you with the tools to implement the six key stages necessary to measure and benchmark your business's environmental performance effectively, and use this information to ultimately determine priorities and to inform decision-making. Following these established best practice methods and techniques will allow your business to minimise the costs associated with a monitoring and benchmarking programme, and allow you to understand your resource use. This guide will also enable you to make informed decisions on how to minimise waste production, thus helping Scotland move towards becoming a Zero Waste economy.

1.3 Why does waste matter?

All companies use resources and produce waste - even small ones. It's a fact of life - almost 20 million tonnes of waste are produced in Scotland each year. As businesses, we can change how much waste we produce, how we manage it and what we do with it.

Many companies underestimate how much waste is costing; it could be as high as 4% of turnover. The true cost of waste isn't limited to the charges for disposal (see Fig 1). It also includes wasted raw materials, energy and labour - which can be between 5 and 20 times more than the cost of disposal. It could cost more to throw resource away than to purchase it in the first place.

Fig 1 The true costs of waste



1.4 Why measure and benchmark?

Measuring and benchmarking should be one of the first steps your business takes in improving its environmental performance. Without a good understanding of resource use, you will be unable to manage these resources in a more efficient manner. Take the time to measure before changing anything. Taking regular measurements, and analysing your environmental and financial data will help you to:

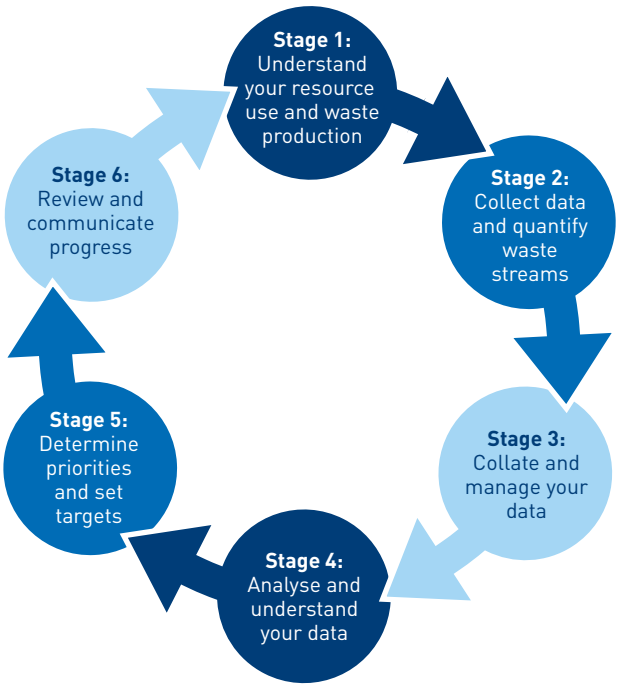
- identify where resources are used in your business;
- control your services/processes more effectively;
- determine the base-line against which to judge the progress of your organisation's resource efficiency programme;
- identify cost-effective opportunities to prevent and reduce waste;
- reduce the true cost of resource use and waste to your company;
- set improvement objectives and targets; and
- measure progress towards your targets and set new ones.

1.5 What is a measuring and benchmarking programme?

A measuring and benchmarking programme comprises a six-stage process (see Fig 2) that takes you from understanding your business's current resource use and waste production, to understanding how to measure it, using the data to understand why and how it is being used and ultimately making informed decisions on how to improve and reduce it to achieve cost savings. This is followed by a review of progress and communication of achievements that take you back to the beginning of the cycle. This guide will lead you through this process, providing a number of techniques and methods at each stage.

Remember: if you don't measure it, you can't manage it.

Fig 2 Key stages in developing your measuring and monitoring programme



2 Stage 1: Understand your resource use and waste production

An initial review will help you to have a better understanding of where resources are used in your organisation along with an idea of the materials you dispose of as waste

Overview

This section focuses on enabling your organisation to identify the resources that are used in its processes and day-to-day operations, and those that are disposed of as waste.

Topics

- Initial reviews:
  - key actions to take.
- Process mapping:
  - key steps.

Outcomes

- Understand the resources used by your organisation and the types of waste produced.
- Begin to understand where these resources are used and why and where waste is produced.

The first step is to understand how your company uses resources (raw materials, components, water, energy, etc) and why waste is produced; the key outcome being to decide what measurements you need to take to monitor performance and then to gather these data on a regular basis.

Your collected data will help you to:

- track performance over time; and
- highlight areas for improvement by comparing your data with established key performance indicators.

2.1 Initial reviews

An initial review can help in gathering basic information. It will help you to have a better understanding of where resources are used in your organisation along with an idea of the materials you dispose of as waste. This information can be used to inform you about the areas that you need more details on. In addition, it can be used to highlight opportunities for quick savings from no-cost and low-cost measures or measures with a short payback period. This will help secure buy-in from senior management to devote more time and resources into the development of your monitoring programme.

2.1.1 Key actions to take

- Have a brainstorming session about your organisation and make a list of as many areas as possible where the activities have environmental impacts. A checklist of the types of resources/activities that are likely to be included is given below.
- Walk around your site looking for areas of resource use, waste and potential improvement. Take photographs of obvious areas of waste.
- Draw up a checklist that covers resource use, waste produced, what you currently do with it and any estimates of quantities. Talk to key people in all departments.
- Determine what information is available from invoices and meters on amounts and costs for raw materials, utilities and wastes.
- Estimate the potential savings associated with a few of the more promising opportunities to reduce resource use.
- Begin to identify where there are gaps in your data and start thinking about how to address them.

Checklist for initial review

- Utility use (e.g. electricity, gas, water).
- Raw material use (e.g. paper, cardboard, packaging, process materials).
- Resources disposed of (e.g. food waste from canteen, offcuts, excess packaging, paper, cans, bottles).
- Fleet transport.
- Staff commuting.
- Customer travel.
- Organisation/process-specific examples.

2.2 Process mapping

An initial review will have provided you with an insight into what resources are used in your organisation and where you generate waste. Producing a flow chart of material and waste flows (a process map) will help you to further understand how exactly resources are used, and which measurements will help you to save money by controlling and reducing waste.

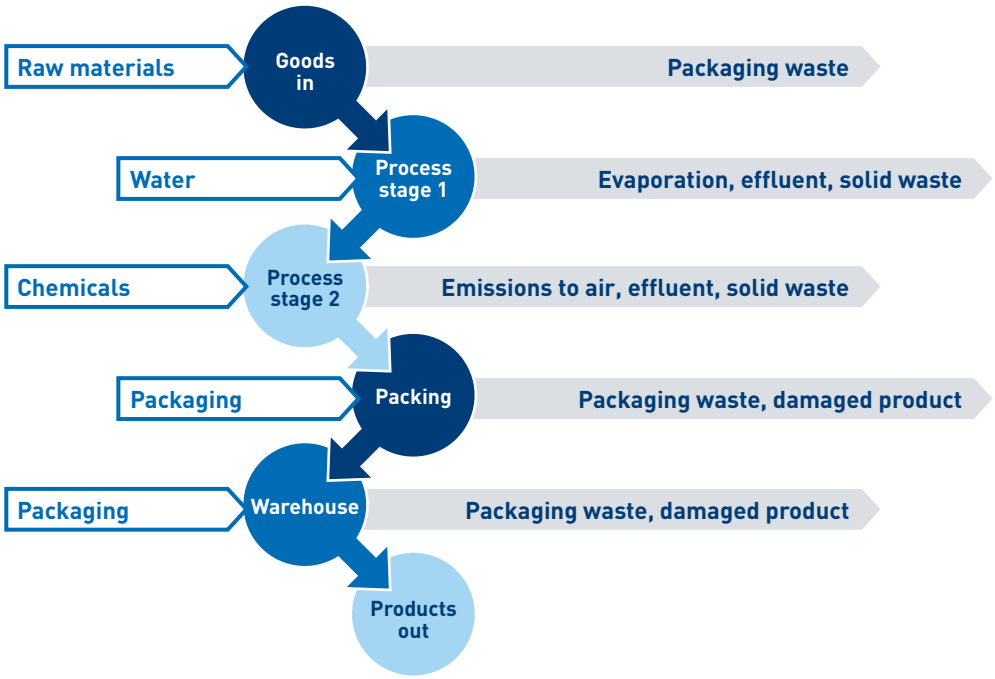
2.2.1 Key steps

- Identify your company's main inputs and outputs. Start by looking at your company or site as a whole and identify the raw materials and utilities used, and the wastes produced.
- Present this information visually as a process map for the site (see Fig 3).

This visualisation is a useful tool to be able to very quickly identify:

- the material and waste flows you need to measure;
- the areas of the business producing the most waste;
- the areas requiring priority attention; and
- waste saving opportunities with the greatest potential for cost savings.

Fig 3 Process map for a sample business



Your process map will act as the basis or framework for your measuring programme. Once you have completed an accurate representation of your business, the next step is to add further details into it. Key areas to look at are:

- what materials and resources are being used/produced at each stage;
- how much of each is being used/produced;
- where inputs go and outputs come from; and
- who could be responsible for measuring.

Your process map can then be used to inform you about those areas that you might want to monitor more closely. It is not necessary to start monitoring every resource and waste stream straight away. A priority list could be drawn up to include considerations such as:

- cost to the business;
- priorities identified in your environmental management system;
- customer and stakeholder demand; and
- environmental impact.

3 Stage 2: Collect data and quantify waste streams

Overview

This section focuses on methods of assessing the quantities and types of resource used/waste produced.

Topics

- Sources of data:
  - taking measurements;
  - estimating;
  - financial data and bills; and
  - mass balances.

Outcomes

- Understand the composition of waste and resources used by your organisation.
- Identify the sources of data available to you.
- Quantify resources use/waste produced.

Key facts to remember when collecting data, regardless of the source are:

- be consistent - make sure the same units are used and the data are collected in the same format;
- carry out data collection on a regular basis (once a month is recommended as a minimum); and
- assign ownership and responsibility.

3.1 Sources of data

Once you have an idea of what the inputs and outputs are for your site, the next step for all businesses is to try and add some quantification to the areas you wish to focus on. Some data may already be available on site (e.g. from existing meters, invoices and purchasing records) and these sources could have been identified during your initial review and process mapping. Table 1 provides an indication of some of the most common sources of information. However, where the data are not available or not in a useful format, there is a range of techniques that can be used to provide you with further clarity on your resource use. **Some data can be collected, but some may have to be estimated.**

Please note - to allow meaningful comparisons, it is important to be able to relate your data about raw materials, utilities and waste to a suitable area of occupancy (e.g. office) or unit of production (e.g. weight of product). Therefore, it is important that this is considered in your monitoring programme.

Table 1 Potential sources of information

Item	Potential sources of information
Process inputs	
Raw materials	Purchase records, stocktaking, dispensing records
Water	Invoices, main meter, sub-meters, portable meters
Energy	Invoices, main meter, sub-meters
Process outputs	
Products/by-products	Production/sales figures, stocktaking
Solid waste/ process residues	Waste production records, invoices, disposal/duty of care documents, packaging waste forms, stocktaking (e.g. what waste is in the yard, in skips)
Effluent	Meters, invoices, effluent discharge consents
Emissions to air	Meters, analyses (of composition), process authorisations, solvent inventories

3.1.1 Taking measurements

There are likely to be various ways of obtaining the data you require. The more accurately you can measure these, the easier it will be to identify areas of wastage and inefficiency.

Table 2 shows the accuracy of various methods of measuring raw materials and wastes where there is not a meter available for taking direct measurements of consumption. Resources that are commonly metered include water (though check with your provider as this is not always the case and some properties are based on rateable value), gas and electricity.

Table 2 Measurement techniques

Item	Measurement technique	Accuracy
Deliveries	Weigh delivered materials on calibrated scales or a weighbridge (remember to subtract the weight of the vehicle and/or container).	***
	Count the number of bags/drums/tanker loads. If possible, avoid using this method as it is less accurate.	*
Dispensed material	Weigh small part-filled containers/bags on calibrated scales (remember to subtract the weight of the packaging).	***
	Fit piped systems with accurate flow meters and, where possible, use electronic data loggers.	***
	Count the number of metered doses (e.g. being added to a mixing vessel).	**
	Decant from large containers such as drums using set measures such as litre jugs.	**
	Count the number of part bags/drum loads/shovel loads, etc. If possible, avoid using this method as it is less accurate.	*
Stock levels	Fit tanks/silos with calibrated electronic level meters (volume) or load cells (weight).	***
	Weigh small part-filled containers/bags on calibrated scales (remember to subtract the weight of the packaging).	***
	Mark transparent containers suchs as intermediate bulk containers (IBCs) to indicate fixed intervals and sub-intervals (e.g. 10 litres).	**
	Use dipsticks for containers. If possible, avoid using this method but, if used, make sure that they are straight, properly calibrated and placed vertically into the container (preferably through a fixed guide tube).	*
Wastes	Weigh your waste or get your contractor to weigh it (e.g. on a vehicle or use a weighbridge).	***
	Count the number of full or partly filled drums or skips. If possible, avoid using this method, as inaccurate volume measurements then have to be converted to even less accurate weight estimates.	*

*** Most accurate; * Least accurate.

The key to taking good measurements is consistency of approach and doing so on a regular basis

Taking direct readings from your meter will provide the most reliable method of determining usage. However, make sure you understand how to read your meter correctly and check the units as there are several meter types in use. **The key to taking good measurements is consistency of approach and doing so on a regular basis.** Generally, once a month is ideal. However, it may be necessary to do more regular readings occasionally to provide greater clarity on consumption patterns. A useful technique where the site is periodically closed (e.g. at night or weekends) is to take meter readings at the start and end of this period to allow you to understand your base-load consumption, which can be a key area to target.

Fig 4 Common types of meter

3.1.2 Estimating

The ideal situation would be to monitor every flow continuously and to measure every single discrete item. While it is possible to measure some items completely, it is generally far more practicable to take occasional readings and samples, and to estimate unknowns. However, it is important to derive reasonably accurate estimates. The two main ways of doing this are outlined below.

Data sampling

Data sampling provides an approximation to the result for the whole 'population' of data. However, care is needed to obtain a representative picture. For example, when taking samples in groups (e.g. four readings each day), the mean average of the readings will give a representative figure for that period. The larger the sample size, the greater the confidence that can be placed in a value estimated from the mean.

Key facts to remember when data sampling include:

- sample sizes should be as large as possible to ensure data are representative;
- sample over a representative period (e.g. over a whole day, a shift or production cycle) to give the most representative picture;
- note any assumptions made when scaling up the values (e.g. work 250 days a year vs 365 days a year);
- the accuracy of the data in, equals the accuracy of the data out - provide as much detail as possible in your initial measurements.

Carry out trials

Experiments or trials can be used to gather sample data. For example, data on liquid flow and evaporation can be gathered simply.

- Use a stopwatch to record how long it takes for the level to change in tanks/large containers of a known volume. This measurement allows the flow rate to be calculated.
- The 'bucket and stop watch' approach can be used for low-pressure flows of non-hazardous liquids. This involves disconnecting pipes or opening valves, and timing how long it takes to fill a container of known volume.
- To estimate evaporative losses, time how long it takes for the liquid level to drop in a container at conditions (temperature and airflow) roughly equivalent to the process of interest.

3.1.3 Compositional analysis

Waste is often an area where many organisations struggle to get an accurate picture of the type and quantities of materials disposed of. Carrying out a compositional analysis can provide a useful indication of types and quantities of materials your organisation produces.

The key to understanding your waste stream is segregation

Table 3 provides some guidance on possible sources of information. The key to understanding your waste stream is segregation. From this, you will know accurately what is in each bin or skip and this can help you to reuse/recover the valuable materials present. If this is not possible (e.g. due to space limitations) a very useful exercise is to conduct a bin audit that can be as simple as:

1) count the number of each type of bin in your organisation;

2) determine how often these bins are emptied; and

3) look in your bins to see what is there and estimate the proportion of each type of material or empty all of your bins and separate out and weigh the different components.

Using the results of your bin audit, combined with information on the size of bin and the frequency of uplift, you can calculate the average weight of each waste stream. This can be done by using conversion factors available from the Scottish Environment Protection Agency (SEPA) (see Table 4). The calculation is illustrated below. Consider how tightly packed the material is in a bin when estimating how full it is.

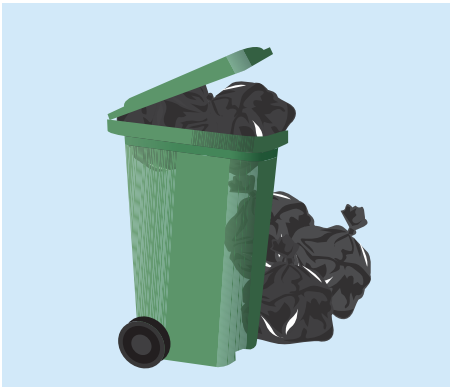
Top tip: Using clear bags during your trial will allow you to see easily what is being disposed of in your bins.

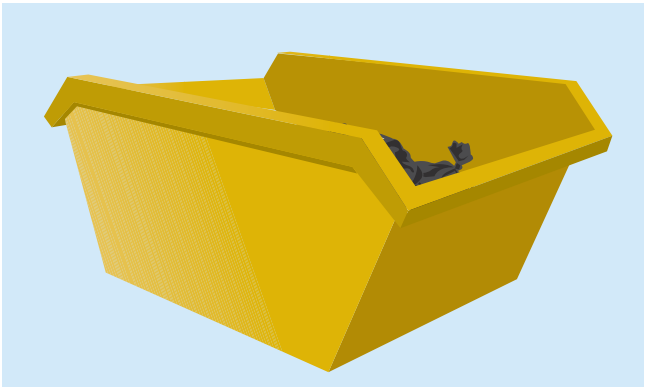
Table 4 Typical skip densities

Material	Tonnes/m^3
Paper and cardboard	0.2105
Glass	0.3332
Biodegradable kitchen and canteen waste	0.2
Plastics	0.14
Metals	0.23
Mixed municipal waste	0.26

Table 3 Sources of composition data

Item	Possible sources of information
Raw materials	Material/safety data sheets provided by suppliers Laboratory analyses of samples
Wastes/ emissions	Monitoring equipment (can measure solids/particulate content and chemical composition Waste/effluent sample analyses (if mixed or altered by additions/processing) Duty of care transfer/consignment notes





Worked example

A company disposes of two 240-litre (0.24m^3) bins on a weekly basis and wishes to estimate the total weight of paper and cardboard disposed of on an annual basis. A visual inspection showed the bins were about 60% full for each uplift. A bin audit revealed that the contents were:

- 50% paper and cardboard (material Z in the calculation);
- 25% plastic bottles; and
- 25% kitchen waste.

Weight Z (tonnes) = conversion factor x bin volume (m^3) x fill rate x % of material Z

= 0.2105 x (0.24 x 2) x 0.6 x 0.5

= 0.03 tonnes/week

Annual weight of cardboard disposed of

= 0.03 x 52

= 1.56 tonnes/year

3.1.4 Financial data and bills

Where an organisation does not have direct access to meter readings, it is possible to determine consumption based on billed data. Billed data will often be held by the finance team who can be approached to obtain a copy of the bills. When using financial and billed data, there are several important considerations.

- Make sure you understand what units the bills are using. For example gas can be measured in cubic feet, cubic metres or kWh.
- Make sure you know which figures relate to your actual consumption, especially when using financial data, as many bills have other charges included (e.g. standing daily charges, meter chargers and Climate Change Levy).
- Check if a reading is based on actual consumption or an estimated reading.
- Bills are often only produced monthly at best, though quarterly or even annual bills are common. This means you could lose a lot of granularity in your data and be unlikely to spot any abnormal usages or pick out trends.
- Be aware of fluctuations in price, which may mask any changes in consumption patterns.
- Water bills can be based on consumption when you have a meter or rateable value if you don't. The latter will not give you an indication of your consumption.
- The level of detail and format of bills vary, so time should be taken to make sure you understand what you are using and pay particular attention if you switch suppliers.
- Waste bills from your contractor can vary greatly in the level of detail provided. Some give only numbers of uplifts, but others are able to provide a breakdown by weight and composition. Ask your supplier if you are unsure or want to discuss other options available to you.

In an ideal situation, your organisation should carry out its own meter readings. These can then be used to sense-check the billed data, which will allow for greater transparency in the data and allow for more meaningful conclusions to be drawn. However, financial data can be useful to help calculate savings figures and will often be required to obtain management commitment. Therefore, it is useful to capture financial data, but these should only be used alongside consumption figures.

The mass balance technique is particularly useful when applied to water use

3.1.5 Mass balances

A mass balance is a method used to estimate quantities of resource used and disposed of in your organisation. It is based on the principle of 'What goes into a process must come out in some form - as product, by-product, solid waste, liquid waste or gaseous emission'. Inputs must equal outputs in a mass balance and this can allow you to estimate the amount of an output that is difficult to measure. This technique is particularly useful for estimating leaks and losses due to evaporation that cannot easily be metered.

The inputs and outputs of a mass balance must be given as a common unit of weight (e.g. in tonnes or kilograms). However, volume (e.g. litres or m^3) can be affected by temperature and pressure and, therefore, the inputs and outputs may not necessarily balance.

To prepare a simple mass balance:

- Determine, as far as is practicable, the quantities of raw materials used and wastes produced in a given period (e.g. a year, month, week or day). Mark these on your process map.
- Where possible, convert quantities to a common unit (e.g. tonnes or kg (1 tonne = 1,000kg); m^3 or litres (1m^3 = 1,000 litres).
- Take account of stock. Mass balance calculations should include stock gains and losses, so use a period between stocktakes as the basis for your calculations.
- Use the data you have available to determine the total weight of inputs and outputs to the site as a whole or one stage of a process/production line. A mass balance can be applied to all materials combined or to an individual material.
- Any discrepancy in your mass balance should be accounted for by the materials or wastes you are trying to estimate.

Water mass balance

The mass balance technique is particularly useful when applied to water use. Water that comes into a process must either leave as effluent, evaporate or be retained in the product (chemically or temporarily as it dries out).

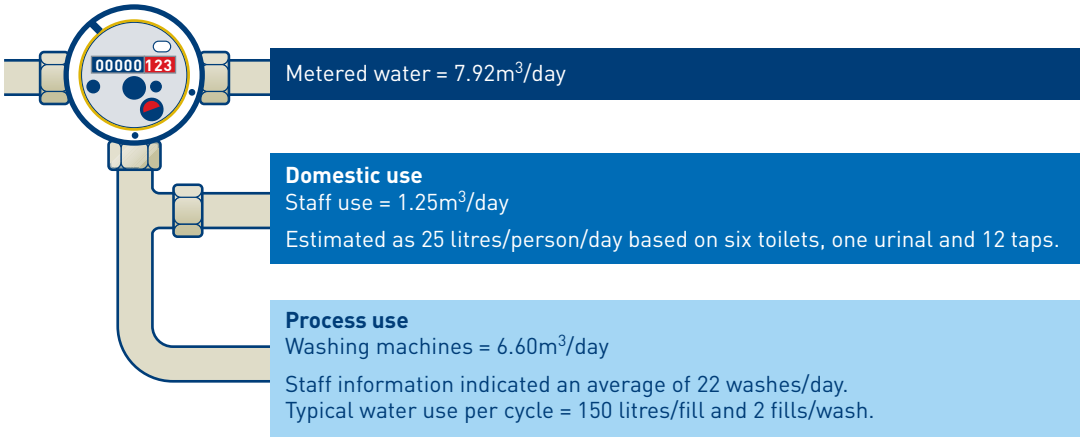
The water mass balance and typical daily consumption figures can be used to highlight:

- where water losses are occurring; and
- where cost savings could be made.

Fig 5 shows a simple water mass balance for a clothing manufacturer. In this example, consumption figures have been calculated from staff observations and measured use.

In the example, domestic and process use together account for 7.85m^3/day (i.e. 99% of the water supplied (7.92m^3/day)) as recorded from actual meter readings. This small discrepancy suggests that there is unlikely to be a water leak or other loss from the system (e.g. evaporative loss, retention of water in product).

Fig 5 Simple water mass balance



4 Stage 3: Collate and manage your data

Spreadsheets are a useful tool to use to log, save and manipulate data

Overview

This section will look further at how best to manage and collate the range of data sources available to you.

Topics

- Storing data.
- Data management best practice

Outcomes

- To understand how to collate and manage your data in a useful format.
- To begin to understand how to look at your data and identify what they are showing.

4.1 Storing data

Organisations will each have their own way of storing and managing the data that they hold. As a minimum, when storing data, you will require the following information:

- period covered;
- value and units;
- location; and
- notes on assumptions/method used to derive figures.

Spreadsheets are a useful tool to use to log, save and manipulate data.

For the purposes of gathering regular information, you may choose to use paper-based log sheets (e.g. for designated people in production to take electricity and gas meter readings). Then have a further designated person responsible to enter these data on a regular basis into the spreadsheet. There are many different methods to track and analyse data. Use the example template on page 13 to get started and adapt it as you need to for your own organisation.

4.2 Data management best practice

There are several best-practice factors for data management.

- Consistency is vital - include measurement units and dates.
- Data should be collected on a regular basis - at least monthly.
- All electronic data should be held in a central system with daily back-up.
- The system used should be expandable and use different formats of data.
- The system is password protected with limited access and the majority of access is read only.
- Paper records are stored in a secure location, kept for a timeframe set by relevant regulation. Copies of all primary data are kept in chronological order and in good condition. Access is restricted to key individuals.
- Each data set has a clear owner and responsibilities are outlined.
- Procedures for data collection should be documented to allow for succession planning or absences of key individuals.

Sample spreadsheet

Production output	Electricity Meter Reading	Weekly Electricity Usage	Gas Meter Reading	Weekly Gas Usage	Water Meter Reading	Weekly Water Usage	Waste to Landfill	Recycling	Reuse of Packaging
Product shipped (units)	kWh	kWh	m^3	m^3	m^3	m^3	tonnes	tonnes	kg
2462	1230000		611010		53011		0	0	20
2231	1310000	80000	611397	387	53430	419	0	0	35
2859	1390000	80000	611676	279	53914	484	0	0	40
2558	1470000	80000	612123	447	54428	514	2	1.5	38
2415	1550000	80000	613010	887	54945	517	0	0	37
1976	1630000	80000	613651	641	55416	471	0	0	25
2308	1720000	90000	614231	580	55887	471	0	0	34
2691	1810000	90000	615060	829	58440	553	2	1.5	46
3589	1900000	90000	615896	836	57011	571	0	0	170
3215	1980000	80000	616665	769	57612	601	0	0	150
3116	2070000	90000	617420	755	58148	536	0	0	160
2674	2160000	90000	617952	532	58698	550	2	1	180
2783	2250000	90000	618478	526	59271	573	0	0	180
2867	2340000	90000	619243	765	59815	544	0	0	182
2983	2420000	80000	619980	737	60341	526	0	0	170
2519	2510000	90000	620806	826	60871	530	0	0	0
3446	2590000	80000	621689	883	61388	517	2	0.5	0
2767	2870000	80000	622804	915	61851	463	0	0	180

5 Stage 4: Analyse and understand your data

Storing data electronically allows them to be easily manipulated

Overview

This section describes a number of techniques that allow you to monitor your resource use/waste production in relation to a number of key business indicators and enable you to have a more in-depth understanding on what the data show and how you can use them. It provides a progressive range of techniques from simple trends to more complex key performance indicators (KPIs) and carbon metrics.

Topics

- Understanding trends:
  - column charts; and
  - trends.
- Relationships.
- Key performance indicators:
  - choose appropriate key environmental performance indicators (KEPIs); and
  - using your KEPIs.
- Benchmarking.
- Carbon footprinting.
- Carbon metrics.

Outcomes

- Understand what your data are showing you.
- Understand how to develop KPIs.
- Benchmarking your performance.
- Attribute carbon values to data.

Please note - the terminology used in this section refers to Microsoft® Excel®. However, there is a range of other tools available.

5.1 Understanding trends

Storing data electronically allows them to be easily manipulated, and enables you to plot your data on graphs and to develop more insight into what is happening.

Many of the different types of graph described in this section can be produced quickly and easily using a computer spreadsheet.

5.1.1 Column charts

The best approach generally involves the use of graphs, such as a simple column chart, where a comparison is being made against a 'base-line' mean average.

Fig 6 is an illustration of where a column chart has been used to illustrate consumption on a monthly basis with reference to a base-line mean average figure. While the graph shows significant improvement, there is considerable variation over the year. For example, there appears to have been particularly high levels of relative consumption (per unit of production) in periods 3, 4, 7 and 9 (and possibly 8). It is also possible to identify that, compared with the base-line average, the business is consistently performing better.

5.1.2 Trends

It is also useful to look at trends. Fig 7 shows progress towards a target for percentage yield. The raw data alone show large variations from month to month, but the trend line shows a more reassuring upward trend, albeit one that is perhaps levelling off below the target of 80%. This trend line is produced by plotting the three-month running average; this is a plot of the mean average of the three months prior to, and including, the present one (i.e. 3, 2, 1; 4, 3, 2; and 5, 4, 3).

5.2 Relationships

Using simple graphical techniques, such as those illustrated previously, does not always provide you with the whole picture. It is often useful to link resource use with a related business metric (e.g. employee numbers, turnover, yield, etc for a given period), the most suitable of which will depend on the nature of your business.

Fig 6 Example bar graph showing consumption per period

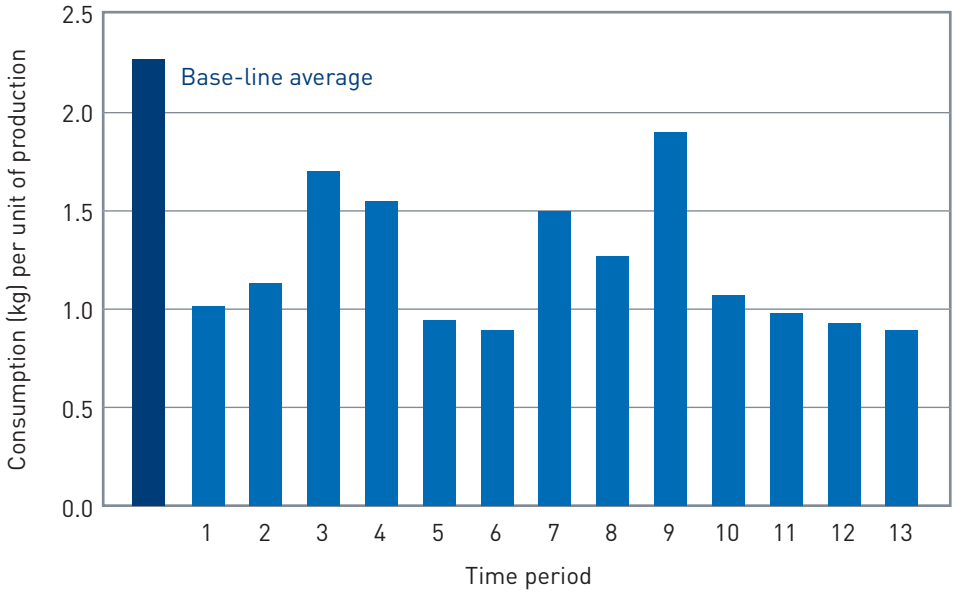
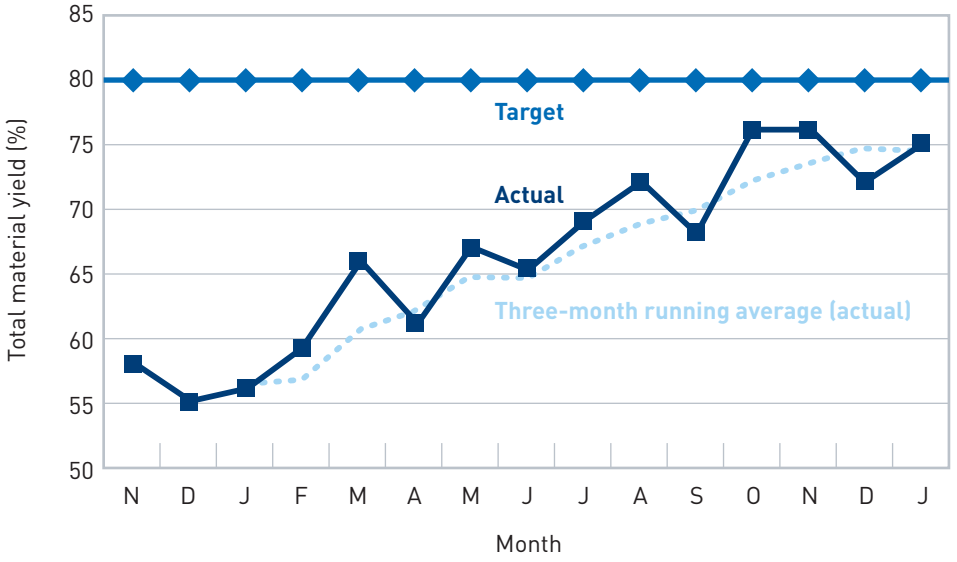


Fig 7 Trend of percentage yield over a 15-month period plotted on a line graph



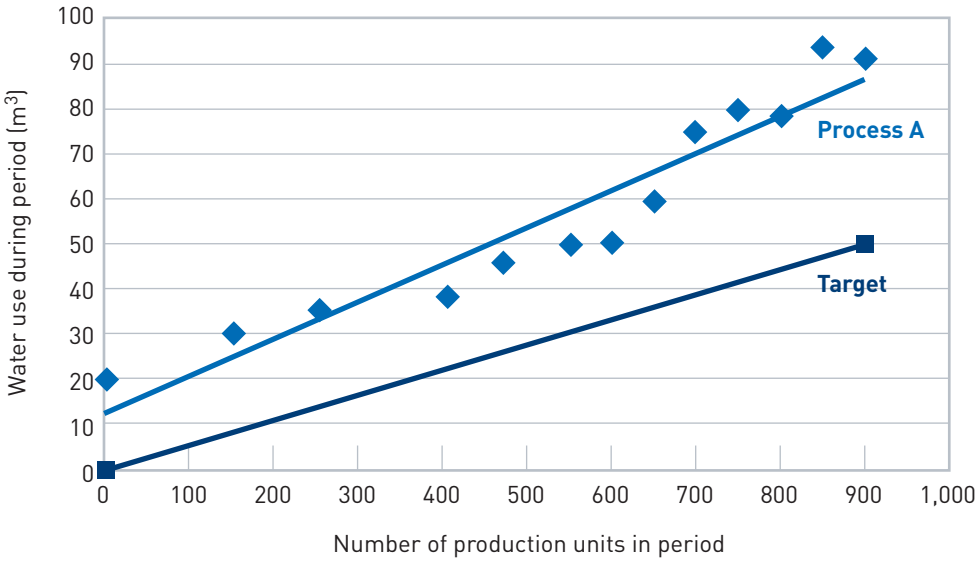
Data can be plotted on a scatter graph (or scattergram) as shown in Fig 8. Scatter graphs are useful when investigating the relationship between material consumption and production, and determining progress against an improvement target. In this type of graph, the various time periods of data collected are scattered about rather than ordered chronologically.

5.3 Key performance indicators (KPIs)

KPIs are the metrics deemed essential to understanding operational health. The key feature of KPIs is that they allow your organisation to understand resource use in relation to business operations and, therefore, allow for changes in production levels, for example, to be accounted for. Measuring performance allows a company to determine

Measuring performance allows a company to determine objectively what is working and what is not

Fig 8 Scatter graph of water use in relation to unit production



objectively what is working and what is not. KPIs can be used to:

- establish base-line performance; and
- track changes.

By setting KPIs, companies are encouraged to measure what they are doing and then establish targets to achieve. KPIs can also be used for external benchmarking (i.e. to measure the performance of a company or product against that of a similar company or product or against 'best practice' data).

This guide focuses on the use of KPIs for environmental aspects (i.e. key environmental performance indicators (KEPIs)). KEPIs are selected criteria covering issues such as:

- material use (e.g. kg of packaging used per item manufactured);
- generation of waste (e.g. kg of waste disposed of per item manufactured);
- carbon emissions (e.g. tonnes of carbon dioxide (CO_2) emitted per tonne of product manufactured); and
- water use (e.g. litres of water used per tonne of product manufactured).

Good KEPIs should:

- help your company understand how changing resource inputs and production parameters can bring about efficiency improvements and deliver cost savings; and
- provide the information your company needs to satisfy its stakeholders (e.g. environmental reporting).

It is important to note that a KEPI that works for one business will not necessarily work for another. Hence, some initial investigation will be required to determine the most suitable KEPI or, indeed, combination of KEPIs to give the fullest picture.

The three main categories of KEPI are:

- absolute indicators;
- relative indicators; and
- weighted indicators.

Absolute indicators. These measure key resources without reference to any other factors, for example:

- litres of water used per year; and
- tonnes of waste produced per month.

These indicators are inappropriate measures of production efficiency where the nature and/or 'volume' of production varies during the period of interest.

Relative indicators. For most companies, the use of relative indicators (sometimes called 'specific measures') is more appropriate. Examples include:

- litres of water used per tonne of product manufactured;
- kg of waste disposed of per item manufactured;
- kg of paper used per member of staff;
- litres of water used per prepared meal;
- litres of water used per member of staff; and
- kg of solid waste recycled per member of office staff.

These indicators attempt to eliminate the 'natural' variation caused purely by production changes and measure only genuine changes in efficiency. Relative indicators can also be expressed as percentages. In this case, the production throughput becomes irrelevant, for example:

- percentage of raw material (input in tonnes) that becomes product (output in tonnes) (i.e. a measure of raw material yield); and
- percentage of effluent reused.

Weighted indicators. Many companies produce a wide variety of products using a range of processes or process variations. For example, a powder coating company might coat door handles one day and whole doors the next day. Measuring production throughput simply as the number of items coated would be meaningless in terms of judging how efficiently the company uses powder coatings. In this case, what is important is the area of the object coated. Another example is when a company wants to measure the efficiency of water use, but some products are solvent-based and others are water-based (and thus use more water in their manufacture). In these circumstances, factors can be applied to give a weighted indicator.

5.3.1 Choose appropriate KEPIs

Choosing the right KEPI for a process is important. Using the data gathered for your company, you need to develop your own KEPIs and then aim to improve them.

The choice of KEPI depends on the type of operation/product, and the company's priorities and those of key stakeholders. Choose appropriate KEPIs covering the full range of issues that are of interest to you and your stakeholders.

The choice of useful KEPIs requires a good understanding of the manufacturing process. Producing a process map will help you to achieve this.

When drawing up your KEPIs, it is important to bear in mind:

- what data are available; and
- what can be measured.

Table 5 lists some common KEPIs.

KEPIs can be tracked and illustrated using the graphical techniques described in Stage 4. Examples of monitoring spreadsheets and a graphical representation are shown below.

It is worth remembering that to fully represent your business activities, a range of KEPIs may be necessary. What works for another business may not necessarily work for you.

Table 5 Examples of common KEPIs

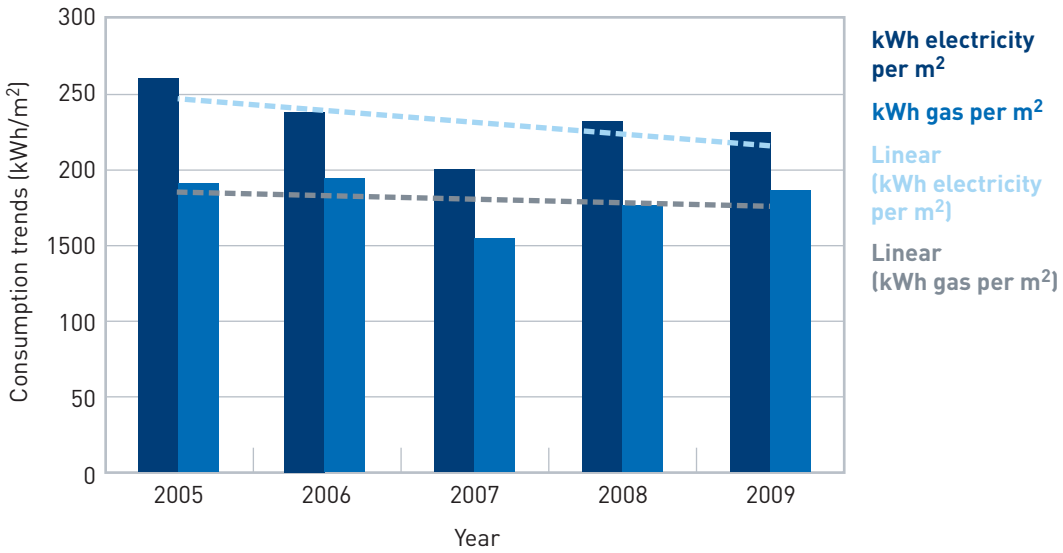
KEPI	Units
Total raw material use	tonnes per tonne of product
Total product yield	% (by weight)
Chemical consumption	litres per tonne of product produced
Water consumption	m^3 per tonne of product
Atmospheric pollutant concentration	mg/m^3
Biochemical oxygen demand (BOD)/ chemical oxygen demand (COD) discharged	kg/tonne of product or kg/ m^3 effluent discharged
Total solid waste disposed of to landfill	tonnes or tonnes per tonne of product produced
Total solid waste recycled	tonnes or tonnes per tonne of product produced
Net packaging use	kg/tonne of product (exclude reuse)
Total energy use: Natural gas Electricity Oil Coal Butane/propane	KWh/tonne of product or tonnes of CO_2/ tonne of product
Fuel efficiency	miles/litre by transport mode or quantity of products (m^2 or kg) per mile or per litre by each mode

Table 6 Key performance indicator tracker

Key performance indicators							
Responsible person	**Per number of employees per month**						
		Measure	**Jan**	**Feb**	**Mar**	**Apr**	**May**
Insert responsible person's name	Number of employees per month	Number	140	140	140	140	140
Responsible person							
		Measure	**Jan**	**Feb**	**Mar**	**Apr**	**May**
Insert responsible person's name	Sales per month	£					
Responsible person							
		Measure	**Jan**	**Feb**	**Mar**	**Apr**	**May**
Insert responsible person's name	Product shipped per month	1,000 units					

The answers will help you to understand what is happening and identify what you need to do to maintain and improve performance

Fig 9 Electricity KPIs presented on an annual basis



5.3.2 Using your KEPIs

Having set up systems to collect KEPI data, the next step is to ask the following questions when analysing these data.

- Is the KEPI moving towards target? If not, why not?
- Is there an external 'best practice' benchmark comparable to your KEPI? If so, what is it and how do you compare?
- Have there been clear periods of inefficiency? If so, what could the causes be?
- How can a repetition be avoided?
- Have there been periods of high efficiency? If so, what were the possible causes? Can adjustments be made to always achieve this higher performance?
- Does the value of the KEPI vary much? If so, why?
- Is the KEPI variation random or systematic? What might the causes be?
- How do other processes/departments/lines compare (internal benchmarking)?
- How do similar time periods compare (e.g. the same period last year)?

Use the graphical techniques described in this section to help you answer these questions easily and quickly.

The answers will help you to understand what is happening and identify what you need to do to maintain and improve performance by improving resource efficiency and reducing waste production.

5.4 Benchmarking

Benchmarking is a useful technique that allows one part of your business to compare its performance with that of another where the processes and operations carried out are similar (internal benchmarking) or it allows you to compare your whole business with that of another business (external benchmarking). External benchmarking can prove challenging as there are few clearly defined sources of industry benchmarks and businesses are not always keen to share these data. Where external benchmarks are used, you should pay particular attention to whether the benchmark is still current, when it was produced along with the type of business to which it applies and any assumptions made. For this reason, this guide focuses only on internal benchmarking.

...can enable you to identify where best practice is occurring and encourage investment and improvement in those areas that are not performing as well

Internal benchmarking can be thought of as simply comparing KPIs of one area with that of another. For example, useful information can often be obtained by comparing different production lines or different time periods. The example in Fig 10 shows data for two production lines, together with the mean average. In this example, just tracking the mean would suggest that the process is reasonably under control (the amount of coating used being between 45g/item and 50g/item). However, the graph reveals that Line 2 shows little variation (i.e. it is 'under control') and coating use is gradually falling, while Line 1 shows considerable variation (i.e. it is 'out of control') and coating use is increasing.

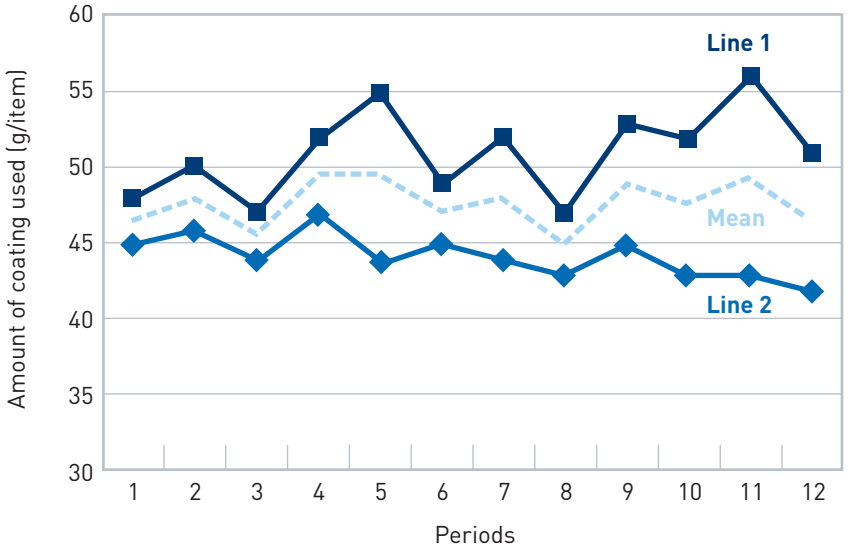
By comparing one area with another through benchmarking, you are able to develop leagues. These can enable you to identify where best practice is occurring and encourage investment and improvement in those areas that are not performing as well. Publicising these league tables internally can also help motivate staff to improve their performance, so they are not at the bottom of the table.

5.5 Carbon footprinting

Carbon footprinting is a tool that has been widely adopted to measure the quantity of CO_2 and other greenhouse gases (GHGs) that are produced directly and indirectly as a result of an organisation's operations. As most organisations have a wide range of operations and activities, they have a corresponding wide range of emissions sources (e.g. travel and transport fuel, waste, and electricity, gas and water consumption). These emissions have different levels of impact on the environment (e.g. methane is more damaging to the environment than CO_2 by a factor of 21). Therefore, to get a meaningful comparison between the various GHGs, conversion factors are used to convert the quantities consumed into tonnes of CO_2 equivalent (CO_2e).

The Greenhouse Gas Protocol[1] and Department for Environment, Food and Rural Affairs's (Defra's) Company Reporting Guidelines (CRGs) provide best practice guidance on assessing carbon footprints. The Greenhouse Gas Protocol is the most widely used international accounting tool for government and business leaders to understand, quantify and manage GHG emissions.

Fig 10 Benchmarking two production lines



[1] www.wri.org/project/ghg-protocol

5.6 Carbon metrics

The Zero Waste Plan in Scotland has introduced a new carbon metric, reporting of which is intended to assess the potential carbon impact of different waste streams. The Carbon Metric Reporting System for Recycling Performance is intended to inform waste policy and to promote a reduction in the environmental impact of resource use. It is not intended as a carbon reporting tool for the UK or Scottish Climate Change targets, and is not suitable for comparing and changing the materials used by businesses or households. It is designed as a decision-making tool to prioritise the prevention, reuse and recycling of waste with the highest environmental benefit. It will allow stakeholders to make informed strategic decisions to the benefit of the environment by targeting recycling and reuse of high carbon impact materials.

The Carbon Metric Reporting System For Recycling Performance is intentionally a range of weightings between 0 and 100 based on the environmental benefit of primary resource displacement, with those with the greatest environmental benefit being ranked 100 proportionally down to the least, which is ranked 0. This gives a ranking based on CO_2 e per tonne for each material returned to a virgin material substitute. There will be waste streams that are assigned an identical carbon metric weighting. However, there will be different proportions of these materials in the waste stream that will allow stakeholders to consider which materials will provide the greatest environmental benefit when recycled.

6 Stage 5: Determine priorities and set targets

Overview

This section provides advice on what to do once you have looked at the data you have and will help you to identify priority areas to target, how to go about setting targets and how to plan the next stages to improve your environmental performance.

Topics

- Identifying priorities.
- Setting targets.
- Developing action plans.

Outcomes

- Understand how to use your data to determine priorities.
- Setting targets for improvement activities.
- Action planning.

6.1 Identifying priorities

Armed with information on the likely causes of waste, and the potential costs and benefits, the next stage is to decide which areas and improvement options should have priority.

6.1.1 Ranking options

Table 7 shows a simple screening approach to the prioritisation problem, which ranks and compares the relative cost, chance of success and environmental benefit of a number of improvement options.

This is a subjective technique. For example, if assessing in relation to environmental benefit, this involves awarding points 1 to 5 to the options based on the waste hierarchy. Elimination of waste scores 5 points, reduction 4 points, reuse 3 points, recycling 2 points and recovery 1 point. A similar screening process can be used to assess the cost and chance of success. For cost, the points are based on payback periods of one to five years, with the shortest payback receiving the greatest number of points. For a chance of success, screen the options in relation to 1 awareness, 2 staff training, 3 operational procedures, 4 monitoring requirements and 5 technology improvement - with the options requiring least intervention scoring more points. Therefore, the priority is a sum of the different ranks given to each factor. If some areas are more important to your business than others, then you can add weighting to the different factors.

6.2 Setting targets

Once you have understood exactly what resources you use and the priority areas you want to influence, the next stage is to set targets to portray your ambition and to give you a goal to work towards. Targets should be set so they are SMART (simple, measurable, achievable, realistic and timebound). Remember that these can be revised if necessary.

Table 7 Simple ranking matrix

	Relative cost	Chance of success	Benefit	Overall priority
Option 1	£££££	✓✓	✓✓✓✓	6
Option 2	££	✓✓✓✓	✓✓	1
Option 3	£	✓✓✓✓	✓	2
Option 4	£££££	✓✓✓✓✓	✓✓✓✓	3
Option 5	£££	✓✓✓	✓✓	5
Option 6	£££	✓✓✓	✓✓✓	4

It is important to be ambitious but realistic, and to aim for evolution rather than revolution

6.3 Developing action plans

Having considered the various options and identified priorities for improvement, the next step is to prepare an action plan. This should set out:

- the major problem areas/causes identified by your monitoring programme;
- clear overall aims and objectives;
- targets (e.g. to improve raw material yield by 10% over the next year);
- proposed priority improvement measures;
- key implementation steps for each measure;
- relevant equipment/material needs, costs, etc;
- team roles and responsibilities;
- timescales for action; and
- the date of the next review.

It is important to be ambitious but realistic, and to aim for evolution rather than revolution.

While a regular programme of data gathering and analysis is essential for the success of your monitoring programme, it is also necessary to occasionally stand back and review progress against targets. Progress should be reviewed regularly, say every six months or year.

- Review progress against targets and, if necessary, revise your targets.
- Review your action plan in terms of changes to the process, production line, product, site, etc.
- Look at how successful process monitoring and data gathering have been.
- Look at how successful the waste minimisation team itself has been. It may be necessary to change team members and even the co-ordinator as the work progresses.

7 Stage 6: Review and communicate progress

Communicating progress to your staff, customers and stakeholders is vital for the success of any environmental programme

Overview

This section provides a brief overview on how you should be reviewing your data and on how to communicate the progress that has been made.

Topics

- Review progress.
- Communicate progress.

Outcomes

- Understand the need for progress review and what considerations should be taken.
- Recognise the range of communication strategies available.

7.1 Review progress

Once you have established your monitoring programme, and begun to identify and implement your action plan, it is important to regularly review your data. This review will not only allow you to see the progress you have made and the results of actions employed, but it may also help you to obtain investment for future programmes or contribute towards a business case. Some key facts to remember when conducting a progress review include:

- ensure all the relevant stakeholders are involved in your progress review (this includes data owners, process managers, environmental team, etc);
- conduct a review regularly (ideally quarterly);
- make sure the data are presented in a useful and meaningful format;
- have clear criteria against which you are assessing the progress made; and
- identify why a project is (or is not) performing as expected.

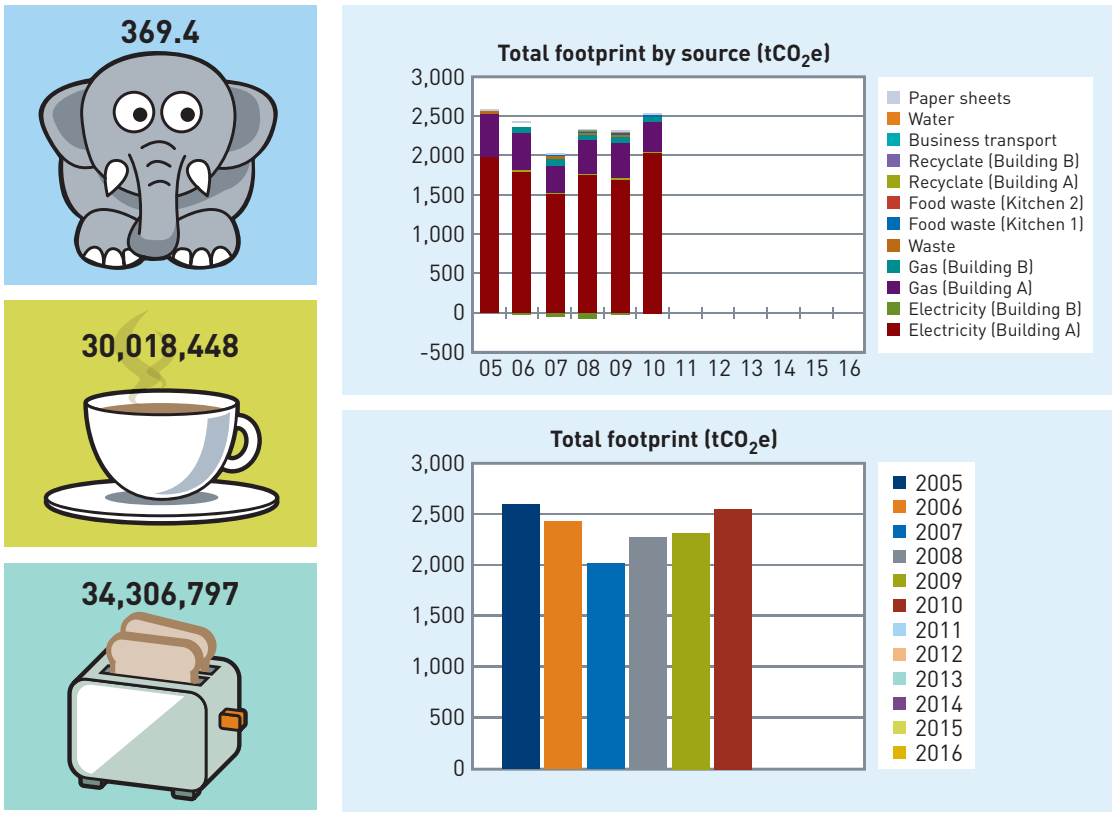
7.2. Communicate progress

Communicating progress to your staff, customers and stakeholders is vital for the success of any environmental programme. This will help motivate the staff and help achieve their buy-in to improvement actions you are taking to reduce the environmental impact of your business. There is a range of methods available to you - some commonly used examples are listed below:

- graphs illustrating progress towards a target;
- converting the data into more meaningful values or values that someone can relate to (e.g. weights can be converted to number of elephants, energy figures can be converted to slices of toast or cups of tea);
- adding financial values can make employees aware of just how much certain actions are costing the business;
- publicising data on your intranet, staff newsletter or notice boards; and
- e-mail updates.

Fig 11 provides an illustration of some of these methods.

Fig 11 Illustration of possible communication methods



8 Summary outcomes

The following checklist provides a summary of what you should now be able to do after working your way through this guide.

Gathering your data	☑
Understand the types of resource used and waste produced by your organisation	☐
Begin to understand where resources are used and waste is produced	☐
Identify the sources of data available to you	☐

Storing and managing your data	
Understand how to collate and manage your data in a useful format	☐

Understanding your data	
Begin to understand how to look at your data and identify what they are showing	☐
Understand how to develop key performance indicators	☐
Benchmark your performance	☐
Attribute carbon values to your data	☐

Next steps	
Understand how to use your data to determine priorities	☐
Setting targets for improvement activities	☐
Begin to develop an action plan	☐
Communicate your results and progress	☐

9 Further information

You may encounter challenges along the way while trying to implement a measurement and benchmarking programme. If you have a specific query or require more information on an area covered in this document, please visit **www.zerowastescotland.org.uk** or contact the **Zero Waste Scotland Helpline 0808 100 2040**.

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