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Managing the Environmental Change Process – How to Use Waste Minimisation as an Effective Tool for Business Improvement

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Dedicated to my parents

Nena Real and José Ferreira de Oliveira

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ABSTRACT

In the Business sector there is increasing pressure for organisations to embrace Sustainable Development - but what does it really mean for the Small and Medium-Sized Enterprise Sector? While this concept has received considerable attention in the academic literature, legislation and common language, it has perhaps inevitably lost some of its precision. Within business ventures in the industrialised world, sustainable development has only been applied in a few bigger enterprises. Given that Small and Medium-Sized Enterprises (SMEs) make up the majority of manufacturing capacity in industrial economies it is worthwhile to examine the concept in order to assess its relevance to the specific needs of SMEs.

The author proposes in this research that a very successful way for SMEs to contribute positively towards sustainable development and indeed to survive in a highly competitive environment is to embrace waste minimisation. The author reports that smaller businesses appear to see waste minimisation as peripheral rather than integral to sound and competitive business practice. She argues that waste minimisation can in fact be the key driver for sustainable change within the Small and Medium-Sized sector.

The author reports upon her participation in two European Regional Development-funded projects, namely the *Environmental Enterprise Project*, and the *Environmental Mentoring Project*, assisting SMEs to establish waste minimisation programmes. These projects served the purpose of gathering raw data for analysis. The projects spanned 3 years and, during that time, a novel waste minimisation methodology was developed which generated cost savings and environmental benefits.

The principal findings of this research are (i) the waste minimisation methodology can be effectively used to achieve cultural change within the organisation, (ii) defining waste as *"anything that doesn't add value to the customer"* enabled the companies to more readily understand waste and thus positively contribute to business improvement.

ACKNOWLEDGEMENTS

This thesis represents the account of a voyage of discovery that started almost eight years ago, when starting a Business Studies degree at the University of Glamorgan. It was only after completing the degree and work experience in industry that I was given the opportunity to do research in this interesting area of management, environmental and human behaviour area – Waste Minimisation.

Stimulated by this unique opportunity and supported by the University and through a grant from the European Regional Development Fund, I have been fortunate to have developed a satisfying, rewarding and productive partnership between different institutions, companies and other students who allowed me to develop case studies for this research, publish articles and provided me with raw data for the results here presented. I would like to acknowledge the people and institutions who made this research possible.

The author would like to acknowledge the School of Design & Advanced Technology of the University of Glamorgan for believing in me and giving me the opportunity to do this research in the first place. The author would also like to acknowledge the support provided by the European Regional Development Fund without whom this research would not have been possible.

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I would also like to remember the people that were employed during the course of the two projects and that applied the methodologies in the companies. Thank you to Fraser, Rhiannon, Ed, Jonathan and Carwyn.

On a more personal note I would like to thank to my parents, to whom this thesis is

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I would also like to extend my gratitude to some friends, which have accompanied me, Fraser Wilkinson, António Araújo, Prof. Albino Reis who encourage me to do research in the first place, my sister Paula, brother-in-law José., my nephew Tiago and niece Telma.

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ABBREVIATIONS

ARS	Assess Rapid Score
BATNEEC	Best Available Technique Not Entailing Excessive Cost
BPEO	Best Practicable Environmental Option
BS	British Standard
BSI	British Standards Institution
CBI	Confederation of British Industry
CEST	Centre for Exploitation of Science and Technology
CIMAH	Control of Industrial Major Hazards Regulations
COSHH	Control of Substances Hazardous to Health
DoE	Department of the Environment
DTI	Department of Trade and Industry
ECM	Environmental Change Manager
EFQM	European Foundation Quality Model
EHOs	Environmental Health Officers
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
ENVOP	Environmental Optimisation
EPA	Environmental Protection Act
ERDF	European Regional Development Fund
GNP	Gross National Product

HMIP	Her Majesty Inspectorate of Pollution
IChemE	Institute of Chemical Engineers
IIP	Investors in People
IMVP	International Motor Vehicle Program
IPC	Integrated Pollution Control
ISO	International Standards Organisation
IWM	Institute of Wastes Management
JIT	Just in Time
JMA	Japan Management Association
JUSE	Japanese Union of Scientists and Engineers
LAPC	Local Air Pollution Control
LCA	Life Cycle Analysis
MBNQA	Malcolm Baldrige National Quality Award
NGOs	Non Governmental Organisations
PDCA	Plan, Do, Check, Act
SABINA	Sustainable Business in Action
SERC	Science and Engineering Research Council
SETAC	Society for Environmental Toxicology and Chemistry
SME	Small and Medium Enterprise
SMED	Single (-digit) Minute Exchange of Dies

TQM	Total Quality Management
UNCED	United Nations Conference on Environment and Development
US EPA	United States Environmental Protection Agency
WBA	William Battle Associates
WCED	World Commission for Economic Development
WDA	Welsh Development Agency
ZQC	Zero Quality Control

Chapter 1 - Introduction

1.1 - Sustainable Development

"Can we move nations and people in the direction of sustainability? Such a move would be a modification of society comparable in scale to only two other changes: The Agricultural Revolution of the late Neolithic age and the Industrial Revolution of the past two centuries. These revolutions were gradual, spontaneous and largely unconscious. This one will have to be a fully conscious operation, guided by the best foresight that science can provide... If we actually do it, the undertaking will be absolutely unique in humanity's stay on the Earth"

William D. Ruckelshaus, (EPA Administrator under President Nixon and Reagan), 1989 quoted by David Ballard (1999).

In view of diminishing global resources, an increase in the world's population, with their greater appetite for material goods, as well as, the need to protect the ecosystems that sustain the world's productive capacity, the importance of achieving environmentally sustainable forms of development cannot be over stated.

Thomas Gladwin *et al* in their paper on *"Shifting Paradigms for Sustainable Development – Implications for Management Theory and Research"* provide an overview of how sustainable development is viewed by other authors. They report upon sustainable development conceived in terms of vision expression, value change, moral development, social reorganisation, or transformational process toward a desired future or better world. (Gladwin *et al*, 1995).

The United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, was a major event to highlight the fact that businesses and industry play a crucial role in bringing about sustainable development and provided the most widely accepted definition of sustainable development as:

"Development which meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987)

Since the time of the Bruntland report (WCED, 1987), different authors have put forward alternative definitions of sustainable development, sustainable economies, and sustainable

societies. Table 1.1 gives a range of concepts of sustainable development, which were selected by the author as being representative of the majority of mainstream views.

Author	Definition of Sustainability[1]
Barbier, 1987	To maximise simultaneously the biological system goals, economic system goals, and social system goals
The World Conservation Union, 1991	Improving the quality of Human life while living within the carrying capacity of supporting ecosystems
Costanza, Daly & Bartholomew, 1991	Sustainability is a relationship between dynamic human economic systems and larger dynamic, but normally slower-changing ecological systems
Meadows, Meadows & Randers, 1992	A sustainable society is one that can persist over generations, one that is far-seeing enough, flexible enough, and wise enough not to undermine either its physical or its social systems of support
Hawken, 1993	Sustainability is an economic state where the demands placed upon the environment by people and commerce can be met without reducing the capacity of the environment by people and commerce can be met without reducing the capacity of the environment to provide for future generations
Hawken, 1993	It can also be expressed as ... leave the world better than you found it, take no more than you need, try not to harm life or the environment, and make amends if you do
Viederman, 1994	Sustainability is a participatory process that creates and pursues a vision of community that respects and makes prudent use of all its resources – natural, human, human-created, social, cultural, scientific, etc.
John Prescott (Deputy Prime Minister), 1998	Sustainable development is a new and integrated way of thinking about choices right across Government, and throughout society, so that we can all share in the highest quality of life now, without passing on a poorer world to our children

Source: Adapted from Gladwin et al (1995)

Table 1.1 - Representative Conceptions of Sustainable Development

From Table 1.1 above it can be argued that the concept of sustainable development is based upon a perceived need to address environmental deterioration and to maintain the vital functions of natural systems for the well being of present and future generations. Although all these scholars cited here appear to agree at least in the fundamental aspects of sustainable

[1] Definitions quoted from Gladwin *et al* (1995)

development, what does this mean to the *"common people"* (i.e. managers, workers, housewives, etc.)?

David Ballard reports on his paper *"Change for Sustainable Development – Addressing the Culture Dimension"* different opinions of managers he has interviewed over the years as an environmental consultant. These views were translated into Table 1.2.

What does it mean?	Will it happen?
"It means major mind changes – but these are on the way"	"The things we need to do are massive"
"(It's about) making people realise it's not all about GDP but about quality of life"	"Very big – sustainable economic development is clearly not happening"
"Radical changes in the way we think about this are needed"	"Gradual creep will not get us to where we need to get to"
"The word competition needs to be redefined"	"We have a long way to go – a long way in terms of process"
"There is an emerging field of activity, but we can't make sense of it yet"	"Sustainability will occur – I've no doubt about that – nature will find a way whether that will happen in a way that you and I will like is another matter..."
	"I'm a pessimist – I don't think we will achieve it – it does require major transitions"
	"From a biological / ecological standpoint, this is very difficult to achieve"
	"I don't know whether is possible or not – it's an article of faith"

Source: Adapted from Ballard (1999)

Table 1.2 - Different Perspectives on Sustainable Development

From the views presented in Table 1.2, it can be concluded that there is as yet no clear consensus, within the business community, as to what the phrase *"sustainable development"* means *("what can we do about it"* in practice) and if/how it will happen.

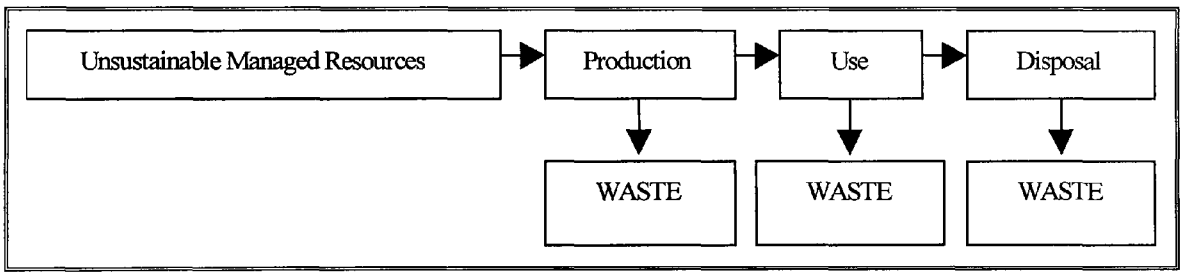
An important pathway towards sustainability for business and industry is the improvement of production systems through technologies and processes that utilise resources more efficiently and at the same time produce fewer wastes.

Industrial production systems require resources: materials from which products are made, energy and utilities that are used to transport and process materials.

Present production systems are linear, often using hazardous substances and finite resources in vast quantities and at high rates. Waste minimisation is ultimately concerned with issues of resource availability and resource consumption: using less natural resources and increasing the efficiency of those which are used with reference to given production levels (IWM, 1996).

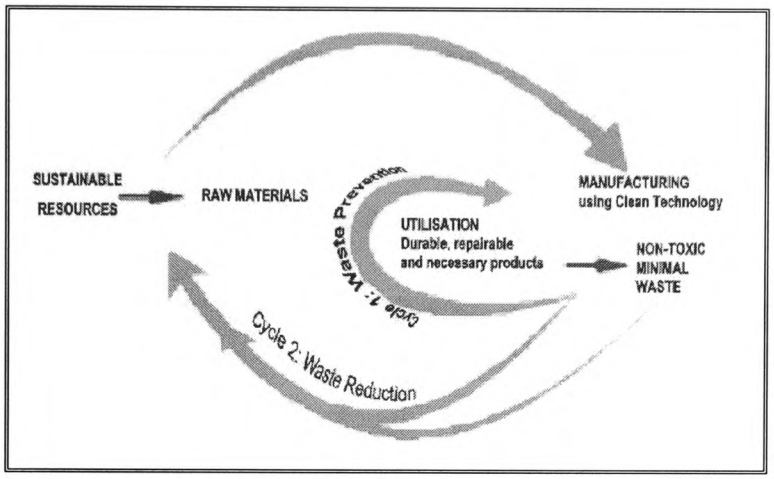
Efficient production systems are circular and use fewer resources. Resources flow through the production-consumption cycle at slower rates. In the first place, a clean production approach questions the very need for the product or looks at how else that need could be satisfied or reduced.

Figure 1.1 and 1.2 (after Cooper, 1994, IWM 1996) suggests how traditional linear models need to be made circular in order to incorporate the principles of sustainable development and allow greater attention to be paid to resources, pollution and environmental degradation.



Source: Adapted from IWM Working Group, 1996

Figure 1.1 - Linear Structure of The Industrial Economy



Source: Adapted from IWM Working Group, 1996

Figure 1.2 - The Circular Structure of a Sustainable Economy

Governments have traditionally approached environmental management by setting standards of permissible pollution loads to water, air and land. Industry has responded by installing end-of-pipe solutions, such as filters.

Some governments have recognised the limitations of this approach and have introduced Integrated Pollution Control for example the UK, and Sweden. However, even these policies fail to recognise that most pollution cannot be controlled. The emphasis must be on prevention.

Waste minimisation implements the precautionary principle - it is a new holistic and integrated approach to environmental issues centred around the product. This approach recognises that most of our environmental problems - for example global warming, toxic pollution, loss of biodiversity - are caused by the way and rate at which we produce and consume resources. It also acknowledges the need for public participation in political and economic decision-making.

Sustainable development does not mean having less economic development. On the

contrary, a healthy economy is better able to generate the resources to meet people's needs, and new investment and environmental improvement often go hand in hand (IWM, 1996).

The global environmental problem is highly complex, various physical environmental issues interact with each other, with population and with international political tensions. The identification of the causes of such problems is equally complex: macro-political and economic factors, technological change, business strategies adopted by companies, individual attitudes and behaviour, they all make a contribution.

Some researchers (Eden, 1996, Freire, 1997, Ghosal *et al*, 1987) have postulated that the solution lies in adopting a broader systems approach to environmental problems rather than giving each and every problem a specific solution.

1.2 - Sustainable Businesses

The main objective of all companies is to obtain success, which is translated in an increase in profit. To achieve this objective they look for strategies, which provide for their customers more value added, than their rivals. The company's competitive performance in the long term is then dependent on the adoption of efficient strategies. As this a widely accepted concept, why then do only a few companies achieve success?

In the beginning of 1980's, an in-depth study of the performance of American companies was made, and showed that successful companies have common characteristics (Freire, 1997):

- Action led;
- Close to customer – interaction and provision of a quality service;
- Autonomy – innovation and taking risks are encouraged and rewarded;
- Productivity through people – individual skills and learning are encouraged;
- Value creation – clarity of all internal and external processes towards a common goal;

- Simple management structure;
- Avoid diversification, unless within the knowledge of the company; and
- Simultaneous centralisation and decentralisation – centralisation of the essential activities of the company and decentralisation through allowing autonomy to all other activities.

Despite the results of this study, several companies analysed such as IBM, K-Mart and Atari, have had several difficulties since then. This discredited the findings of the study. It might be concluded that, although the characteristics mentioned above provide a good picture of a successful company, it is not per se enough to guarantee success in the long term.

To fully understand the determinant of sustainable success for companies it is necessary to provide a definition of success. Although different authors argue about this subject, Freire (1997) reports a definition, which is widely accepted by most authors.

"A Company's success is recognised by the ability to survive in the long run, through the sustainable increase on sales, an adequate return on investment and the ability to demonstrate a capacity to innovate"

Management theorists and consultants have developed a range of models or methods to enable the in-depth analysis of organisational problems and culture issues. These approaches are rarely applied to corporate environmental management in the context of the individual firm, especially if we take the Small and Medium Enterprises (SME) sector.

This thesis argues that an in-depth diagnosis of organisational culture and performance is essential for the identification of underlying factors (or critical success factors) that give rise to such unsustainable practices.

1.3 - Objective of this Work

The objective of this work is to develop a methodology on waste minimisation, which would contribute positively to business improvement, particularly in the SME sector. The author understands as business improvement all the actions taken within the journey for change that

lead the business towards excellence.

1.4 - European Regional Development Fund (ERDF)

The research presented here was co-financed by the ERDF, and sponsors from the private sector, which formed a steering group. The first part of the research was financed under the ERDF project *"Generating Wealth and Job Creation Through The Implementation of Effective Waste Minimisation Techniques"*, and the second part of the research was financed through the ERDF project *"Environmental Mentoring"*.

William Battle Associates were the consultants responsible for overall project management and technical support to companies, and the author worked closely together with it's Managing Director also relating to other similar projects of the company that would be relevant for this research. Since confidentiality agreements were signed with the individual companies participant in the project, the author does not mention any names in the case studies presented. The names of the companies can be made available to the examiner if considered relevant for the purpose of proving the information provided.

1.5 - Dissertation Structure and Content

The following Table 1.4 presents the structure and content of the thesis.

Chapter	Title	Areas Focussed
1	Introduction	Current Chapter. Presents background, objectives, approach, and scope.
2	Waste Minimisation	Defines the different concepts within the area of waste minimisation, overviewing work undertaken by other authors.
3	Environmental Issues & Pressures for Change	Defines SMEs and describes their characteristics and why the author decided to concentrate the focus of the research within this group plus barriers and pressures for change.
4	The Links with Total Quality	Establishes the links of waste minimisation with total quality management, including an overview of tools and techniques used within the waste minimisation methodology.
5	Waste Minimisation in Practice	This Chapter describes the two different ERDF funded projects in which the author was directly involved plus work undertaken by other others in the application of waste minimisation programmes.
6	Application of the Methodologies	The author presents a discussion of the outcomes from the application of the various waste minimisation programmes described in Chapter 5.
7	Critical Success Factors	The author analyses the critical success factors of applying the waste minimisation programme and presents case studies to support the findings of the research.
8	Conclusions & Recommendations for Further Work	In this Chapter conclusions are presented including contribution to knowledge and recommendations for further work to be undertaken in this area.

Table 1.3 - Dissertation Structure and Content

Chapter 2 - Waste Minimisation

The Brundtland report of the United Nations *"Our Common Future"* (WCED, 1987) clearly identified that sustainable development would only be achieved if society in general, and industry in particular, learned to produce *"more with less"*; more goods and services with less use of the world's resources (including energy) and less generation of pollution and waste.

In the era of *"green consumerism"* (Elkington and Hailes, 1988), this concept of *"more with less"* had been taken up by industry and has spawned a range of concentrated products, lightweight and refillable packaging and other innovations (Hindle *et al.*, 1993; IGD, 1994). Changes in production processes, as well as the products themselves, have been introduced, with many companies using internal recycling, or on-site energy recovery, as part of waste minimisation schemes. There was also interest in further promoting waste reduction by the use of fiscal instruments. Pearce and Turner (1992) for example, suggested ways to reduce the amount of packaging used (and hence appearing as waste) by internalising the costs of waste disposal within packaging manufacture, by means of a packaging levy. The EU Packaging Directive came into force in December 1994, and all member states had to set up collection systems for packaging materials.

"Waste Minimisation", *"waste reduction"* or *"source reduction"* are usually placed at the top of the conventional waste management hierarchy. In reality however, source reduction is a necessary precursor to effective waste management, rather than part of it. Source reduction will effect the volume and, to some extent, the nature of waste, but there will still be waste for disposal.

This Chapter provides an overview of the subject of waste minimisation, including important factors such as relevant legislation, tools and techniques and the work of other authors.

2.1 - Definitions

There are many different definitions of waste and classification of waste throughout the world. The interpretation of what is meant by waste can also change with circumstances, e.g. what is waste to one can be a useful raw material to another.

Dictionary definitions of waste include the descriptions *"useless"* or *"valueless"*. In the UK the

legal definition of waste is given in Section 30 [1] of the Control of Pollution Act 1974.

"Waste includes:

- *any substance which constitutes a scrap material or an effluent, or other unwanted surplus substance arising from the application of a process, and*

- *any substance or article which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled.....*

and for the purposes of this Part of the Act, anything which is discarded or otherwise dealt with as if it were waste, shall be deemed to be waste unless the contrary is proven."

These definitions were repeated within Section 75 of the Environmental Protection Act 1990. The "waste" definition has also been tested in the courts (ref. DoE Circular 13/88):

- Long v Brooke (1980)... *"although one man's waste may be another man's raw material, on its true construction, the Act defines waste from the point of view of the person discarding the material"*

- Berridge Incinerators Ltd v Nottinghamshire County Council (1987)... *" In my judgement, the correct approach is to regard the material from the point of view of the person who produces it... something produced as a product or even as a by-product... or is it something to be disposed of as useless?"*

To comply with legislation disposal authorities considered the following to define waste:

- Is it what would ordinarily be described as waste?

- Is it a scrap material, effluent or other unwanted surplus?

- Does it require to be disposed of as broken, worn out, contaminated or otherwise spoiled?

- Is it being discarded or dealt with as if it were waste?

Should the answer be *"yes"* to any of the above questions, then the next step is to consider

whether it is household, industrial or commercial waste, according to its origin.

Further UK and EU definitions of controlled waste, special waste, hazardous waste, toxic waste, dangerous waste, waste oil, inert waste, non-hazardous waste, difficult waste, and clinical waste are provided by Croner's (1991) Waste Management. Reference should also be made to the Institute of Chemical Engineers (IChemE) Guide (1995).

An alternative definition of waste was developed by Taiichi Ohno, Toyota's Chief Engineer, to nearly encapsulate all forms of waste that occur in a manufacturing plant. He postulated that identification of waste is the first stage to its elimination. The 7 wastes identified were productivity rather than quality related, although quality and productivity are closely linked. Improved productivity leads to leaner operations which make quality problems more visible and better quality improves productivity by cutting out wasteful practices such as rework, extra inspection, and all the activities associated with doing an operation for the second time.

The "7 Wastes" categorised by Taiichi Ohno are:

1. Waste of Overproduction
2. Waste of Waiting
3. Waste of Transporting
4. Waste of Inappropriate Processing
5. Waste of Unnecessary Inventory
6. Waste of Unnecessary Motions
7. Waste of Defects

Source: Adapted from Bicheno, 1998

Table 2.1 - The Seven Wastes

The Waste of Overproduction - Ohno believed that the waste of overproduction was the most serious of all the wastes because it was the root of so many problems. Overproduction is making too much, too early or *"just-in-case"*. The aim should be to make exactly what is required, no more or less, just-in-time and with perfect quality. Overproduction leads directly to excessive lead and storage times. As a result, defects may not be detected early, products may deteriorate, and artificial pressures on work rate may be generated. All these increase the

likelihood of defects. Taking it further, overproduction leads to excessive work-in-process inventories that lead to the physical separation of operations and the discouragement of communication. Overproduction should be related to a particular timeframe. At Toyota, overproduction is considered to have occurred if the daily schedule is exceeded.

The Waste of Waiting - The waste of waiting occurs whenever time is not being used effectively. Time is an important element of competitiveness and quality. Customers are not willing to be kept waiting but in most cases they will be prepared to pay extra for speed. In an organisation, any time that materials or sub-products are seen not to be moving (or not having value added) is an indication of waste. Although this waste is very difficult to be completely eliminated, it should be examined very carefully.

The Waste of Transport - Any movement of materials in an organisation is waste, since it is an operation which is not adding value to the product. This waste can never be fully eliminated but over time should be continually reduced. The number of transport and material handling operations is directly proportional to the likelihood of damage and deterioration.

The Waste of Inappropriate Processing - Inappropriate processing refers to waste of machines or processes that are not quality capable; i.e. a process that cannot help but make defects. In general, a capable process requires having the correct methods, training, and tools, as well as having the required standards clearly known.

The Waste of Unnecessary Inventory - Inventory is the enemy of quality and productivity. This is so because inventory tends to increase lead-time, prevents rapid identification of problems, and increases the use of space thereby discouraging communication.

The Waste of Unnecessary Motions - Unnecessary motions refer to the importance of the ergonomics for quality and productivity. If operators have to stretch, bend, pick-up, move in order to see better, the victim is initially the operator but ultimately quality and productivity suffers.

The Waste of Defects - The Toyota philosophy is that a defect should be regarded as a challenge, as an opportunity to improve. This idea of defects as waste has much in common

with the view of *"zero defects"* of Bill Crosby, further explained in Chapter 4.

There are authors that added *"new"* areas to this list of 7 wastes (Bicheno, 1998) and included the waste of untapped human potential, the waste of inappropriate systems, wasted energy and water and pollution waste. Although it is quite easy to understand the last two added wastes (energy and water and pollution) it is more difficult to perceive (and even worse to measure) the waste of people and systems.

Ohno was reported to have said that the real objective of the Toyota production system was *"to create thinking people"*. So, the first of the *"new"* wastes is directly linked to Ohno as were the original seven. This is considered a waste because people are not using their full potential (which is wasteful) if they are not required to think. The waste of inappropriate systems is directly linked with paperwork and bureaucracy (the customer does not want to pay for bureaucracy).

The definition of Waste Minimisation by Crittenden (1995) is:

"Waste Minimisation involves any technique, process or activity which either avoids, eliminates or reduces a waste at its source, usually within the confinements of the production unit, or allows reuse or recycling of the waste for benign purposes". (Crittenden *et al*, 1995).

Synonymous terms include:

- Waste reduction / source reduction (particularly used in the USA);
- Clean technologies / clean engineering / clean processing;
- Pollution prevention / reduction;
- Environmental technologies;
- Low and non-waste technologies; and
- Lean manufacturing.

The concept of waste minimisation explored in a Clean Technology Unit report (SERC,

1994) adds to the previous definition the following:

"... product design to minimise waste at its point of use and through its entire life cycle."

The preferred definition of waste (Interface, 1997) for the author employed throughout this research is:

"Anything that does not add value to the customer"

This is a broad definition that groups quality, productivity and environmental issues. Waste minimisation is then the techniques used to identify and eliminate the non-value adding activities within the process or value chain.

2.2 - Legislation and Compliance

The following is an overview of legislation surrounding the waste management area, in the UK and the EU.

2.2.1 - Control of Pollution Act 1974

Having placed a duty upon local authorities to prepare Waste Disposal Plans to ensure that controlled waste within their domain could be managed, the next major provision in this Act was to make the indiscriminate deposit, or unlicensed treatment, of such waste a criminal offence.

Later Regulations issued under the Act - the Collection and Disposal of Waste Regulations 1988 - refined the definitions of Household, Industrial and Commercial Waste and the activities involving waste for which a license was not required.

2.2.2 - Environmental Protection Act 1990

The Environmental Protection Act 1990 (EPA 1990) is an important piece of legislation in the field of the UK environmental law. It reflected growing public concern for the environment in Britain and was enacted in order to develop existing law perceived at the time of its drafting to be too lax to safeguard the environment effectively.

The EPA 1990 introduced into the UK Law the concept of *"Integrated Pollution Control"* (IPC), and vested the overall responsibility for introduction and maintenance of this strategy with Her Majesty's Inspectorate of Pollution (HMIP). IPC requires consideration of the impact of pollutants discharged into the environment upon all three media: air, land and water. Within this philosophy also lies the principle of the *"Best Practicable Environmental Option"* (BPEO).

Operators of any process or waste management activity must utilise the most effective means to prevent or minimise release of substances from their process. In essence, the operator must use the most effective techniques and technology whilst the regulator must take into account the economic viability of the process in relation to the environmental improvement it will achieve. The process techniques must be appropriate to the scale of operations and must be commercially available. This principle is known as BATNEEC - Best Available Techniques Not Entailing Excessive Cost. The need to achieve BPEO will dictate BATNEEC, since BATNEEC for BPEO should prevail over BATNEEC for release to any individual medium.

The Department of the Environment, Transport and the Regions guide to IPC defines the components of BATNEEC as follows:

- **B**est - most effective
- **A**vailable – procurable and operable with business confidence
- **T**echniques – plant, process and equipment as well as number and qualifications of staff, working methods, training, maintenance
- **N**ot **E**ntailing **E**xcessive **C**ost – in determining what is excessive, possible

environmental damage has to be weighted against the costs of available techniques. For new processes, the effect of necessary investments on the operation's potential profitability is irrelevant. If the application concerns an existing process, costs can be excessive when they result in a disproportionate rise in the finished product's price.

Section 34 of the Environmental Protection Act 1990 imposed a new duty of care on persons concerned with controlled waste. The duty applies to any person who produces, imports, carries, keeps, treats or disposes of controlled waste and carries severe penalties for breach of any such duty. Thus, the management of the waste in all activities must be maintained with due regard for ensuring that the environment is not compromised within reasonable limits.

Under part one of the EPA 1990 the concept of Local Air Pollution Control (LAPC) is established. Industrial processes that are subject to LAPC are often referred to as Part B processes. In Wales and England, there are approximately ten times more part B than part A processes. As with Part A processes, operators are required to prevent, minimise and render harmless releases of prescribed substances to air in accordance with the principles of BATNEEC. BATNEEC still means Best Available Techniques Not Entailing Excessive Costs but it is simpler and less open to interpretation than for IPC processes.

2.2.3 - Clean Air Act 1993

Part one of EPA 1990 is the main legislation that addresses air pollution. However, there are many industrial and commercial businesses that fall outside of both IPC and LAPC. One of the primary purposes of the Clean Air Act is therefore to control emissions of dark and black smoke, grit and dust from the boilers, processes and other activities of any businesses. The Act is administered by local authority Environmental Health Officers and its scope is as follows:

- Prohibition of dark smoke from the chimneys and industrial or trade premises;
- Requirement that new furnaces are smokeless (so far as practicable);

- Limits on the emission rate of grit and dust from boilers and furnaces;
- Arrestment plant for furnaces;
- Measurements of grit, dust and fumes;
- Height of chimneys; and
- Smoke control areas.

The Act includes four permitted periods in which dark smoke may be emitted from chimneys during any period of eight hours. There are also a number of reasons for dark smoke emission that may be accepted as a defence against prosecution. These include starting up a furnace from cold, unavoidable and unforeseeable mechanical failure or unavoidable use of unsuitable fuel.

2.2.4 - Environment Act 1995

The Environment Act 1995, which established the Environment Agency, also laid a duty on the Secretary of State to produce a national waste strategy, in compliance with Article 7 of the EC framework directive on waste. As part of this process, a draft waste strategy was published for public consultation in January 1995. The strategy endorses the *"primacy of waste minimisation"* and notes that it is important to reduce the hazardous nature as well as the quantity of waste produced. The draft lists a number of specific targets to be achieved, by various means, and two examples of these targets are:

- To reduce the proportion of controlled waste going to landfill by 10% over the next ten years and to make a further similar reduction in the ten following years; and
- For 75% of companies with more than 200 employees to have published environmental policies covering waste issues by the end of 1999.

The final strategy was published in March 1997 and commits the Government to achieving major reductions in pollutants by 2005 to meet forthcoming European Community Air

Quality legislation.

2.2.5 - Water Industry Act 1991

Under the Water Industry Act, trade effluent may only be discharged into a public sewer with the consent and agreement of the relevant sewage undertaker (normally the water supply Company). Consents detail the volume and quality of the effluent discharged (e.g. biochemical oxygen demand, pH, and temperature). Breach of the consent conditions, or discharging trade effluent without obtaining consent, can lead to fines.

The essential legal provisions covering water pollution are to be found in six main acts: Water Resources Act 1991, Water Industry Act 1991, Statutory Water Companies Act 1991, Land Drainage Act 1991, Water Consolidation Act 1991 and the Environment Act 1995.

2.2.6 - Water Resources Act 1991

The Water Resources Act tackles pollution of *"controlled waters"* such as rivers, streams, canals, groundwater and the like. Unless the subject of a written consent to the contrary, the Act prohibits discharge (or any other means of entry) to controlled waters of *"poisonous, noxious or polluting matter or any solid waste matter"*. In practice, this is a very strict requirement since it prohibits any substance of any nature from entering controlled waters without consent. As in the case of the Water Industry Act, written consent can be sought to discharge trade effluent (or sewage) to controlled waters and, if granted, compliance with the terms of the consent ensures that prosecution is avoided. However, the consent has to be sought from the Environment Agency.

Consents detail the volume and quality of the effluent discharged, typically covering determinants such as biochemical oxygen demand (BOD), ammonia, pH, temperature and concentration of suspended solids. They could also include stipulations with respect to the toxicity of the effluent. Breach of the consent conditions, or discharging trade effluent without obtaining consent, can lead to fines.

2.2.7 - Environmental Protection (Duty of Care) Regulations 1991

Part II of the EPA 1990 deals with the collection, recycling and disposal of waste. For the purposes of this legislation, waste is defined as any substance or object that is discarded by the business that was responsible for producing it. Since every manufacturer, office or service company produces waste, this legislation affects all firms irrespective of the toxicity or amount of waste produced.

Both Part II of the EPA 1990 and the Environmental Protection (Duty of Care) Regulations place a duty of care on anyone that imports, produces, carries, keeps, treats or disposes of *"controlled waste"* (i.e. waste from your company). This means that a company producing waste is responsible for its proper and safe disposal even after it has been passed on to another party such as a waste contractor, scrap merchants, recycler, local council or skip hire company. In other words, a company's legal responsibility for waste is never relinquished and it is a criminal offence not to comply with the Duty of Care. This applies equally to waste arising from office, production and from construction activities.

2.2.8 - The Special Waste Regulations 1996

There are approximately 250 categories of substance that are classified as special wastes and are therefore subject to the Special Waste Regulations[2]. These categories include acids, alkaline solutions, various types of battery, photographic chemicals, solvents, sludges, washing liquids and waste oils. It is important to note here that the containers in which any of these substances were delivered may also be classified as special waste if, when disposed of, they still contain more than 1% of the original contents.

The Regulations are subject to concentration thresholds below which they do not apply but there are no lower limits on quantities. The Regulations can therefore apply to some very small companies in both manufacturing and service industries. Enforcement of the Regulations is the responsibility of the Environment Agency.

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2 As amended by the Special Waste (Amendment) Regulations: SI2019, 1996 & SI251, 1997

2.2.9 - Producer Responsibility Obligations Regulations 1997

The Producer Responsibility Obligations (Packaging Waste) Regulations came into effect at the end of August 1997, and were amended in June 1999[3].

These Regulations impose recycling and recovery obligations on businesses carrying out packaging activities. For the purposes of the legislation, packaging is defined as any item that is used for the containment, protection, handling, delivery or presentation of goods. Packaging can therefore include such items as boxes, containers, tubes, bags, sacks, pallets etc. made out of paper, cardboard, glass, metals, plastics, ceramics and the like (includes wood from the year 2000). It can also include tape, wrapping, binding and tying materials.

2.2.10 - Contaminated Land

Part IIa of the EPA 1990 was created as a legal mechanism to clean up contaminated land and was inserted in to the Act by section 57 of the Environment Act 1995. Although due to be operational by July 1999, much of the detail has yet to be finalised through statutory guidance and subsidiary regulations. If a company fails to prevent (or continues) contamination of the land in this way, it is likely to incur clean up costs under the legislation when it comes into full operation as well as reduced value of assets and increased insurance costs.

Part IIa of the EPA 1990 gives Local Authorities responsibilities for identifying and facilitating the remediation of contaminated land. They will also have to decide whether the land should be designated as a *"special site"* to be handled by the Environment Agency rather than the Local Authority itself. This decision will be governed by the former use of the site rather than the nature of the contamination.

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[3] The Producer Responsibility Obligations (Packaging Waste) (Amendment) Regulations 1999

2.2.11 - Statutory Nuisance

The Statutory Nuisance provisions of the 1990 Environmental Protection Act require Local Authority Environmental Health Officers (EHOs) to take action against companies causing a nuisance. The legislation applies to the majority of businesses but, for LAPC or IPC process operators, the only focus of Statutory Nuisance is with respect to nuisance from noise.

If an EHO considers that *"a statutory nuisance exists, or is likely to occur or recur"* (s)he must serve an abatement notice which may prohibit or restrict the nuisance, require abatement or require execution of remedial works. Failure to comply with this notice is an offence but it can be a defence against prosecution to show that the best practicable means were used to prevent or minimise the nuisance. This must be determined with regard to local circumstances and available technology in so far as work safety is not affected. No consent or authorisation procedure exists.

2.2.12 - Health and Safety and Associated Environmental Legislation

Apart from the statutory instruments directed specifically at the protection of the environment, derived from the Control of Pollution Act 1974, Clean Air Acts, and the Environmental Protection Act 1990, there are a number of important regulations which derive from certain sections of the Health & Safety at Work Act 1974, and the Food & Environment Protection Act 1985.

These have a dual role in legislating to ensure that inadvertent occurrences involving substances of a particularly dangerous nature in connection with work activities, will have been subjected to risk assessment and controlled to protect other people and the environment. Examples of these are:

- The Control of Industrial Major Accident Hazards Regulations 1984 (CIMAH)

("to protect persons other than those at work against risks to health or safety arising out of or in connection with the activities of persons at work...")

- The Control of Substances Hazardous to Health Regulations 1988 (COSHH)

("provide training for employees in safe working procedures, and protect others who could be affected by activities where such substances are used").

2.2.13 - The Landfill Tax

The Finance Act 1996 introduced a tax for all waste deposited in landfill sites. One of the aims of the landfill tax is to switch waste from landfill - in most cases a fairly cheap option - to recycling or other more environmentally acceptable modes of disposal. By introducing such a tax, the Government is forcing companies to go higher up the Waste Management Hierarchy, which is described later. At the EU level, a draft Directive has been the subject of negotiations and could rule out certain waste disposal practices carried out in the UK and make others more difficult. The result of this would be to make disposal of waste to landfill more costly and would therefore force waste producers to look at alternatives such as recycling and waste minimisation.

Wastes disposed of at a licensed landfill site are subject to landfill tax at a standard rate of £7 per tonne. Certain inactive or inert wastes are subject to a rate of £2 per tonne[4].

2.2.14 - EU Directives

EU waste legislation has developed since the 1970s and is illustrated in Table 2.2. Within the EU, directives are generally used to bring about improvements in environmental protection and these provide flexibility to member states to achieve the aims of the EU in their own way and pace. The UK joined the European Community in 1972. As a result, UK environmental law has become increasingly subordinate to Community legislation (Connell *et al*, 1998). This influence was formalised in the 1986 Single European Act when, for the first time in the EC, protection of the environment was recognised explicitly as one of the objectives of EC law and policy.

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[4] Please refer to SI 1996/1528 The Landfill Tax (Qualifying Material) Order 1996

Initial Directive	*Subsequent amendments*	*Title*
Waste management		
75/442	91/156	on waste
78/319		on toxic & dangerous waste
91/689		on hazardous waste
Waste Transport		
84/429	85/469, 86/279; 87/112; Decision 90/170; Reg. 259/93; decision 94/721	on supervision & control within the EU of the transfrontier shipment of hazardous waste
Waste Treatment and Disposal		
89/429		on the reduction of air pollution from existing municipal waste incinerators
89/369		on the reduction of air pollution from new municipal waste incinerators
94/67		on hazardous waste incineration
COM (93)275		proposal on the landfill of waste
Waste Products		
75/439	87/101	on the disposal of waste oils
76/403		on the disposal of PCBs and PCTs
85/339		on containers of liquids for human consumption
91/157		on batteries and accumulators containing certain dangerous substances
Waste Emissions		
76/464	82/176, 83/513, 84/156, 84/491, 86/280, 88/347, 90/415	On the discharge of dangerous substances
78/176	80/779, 84/360, 89/428, 92/112	on waste from the titanium dioxide industry
80/68		on the protection of groundwater against pollution by certain dangerous substances
86/278		on the protection of the environment when sewage sludge is used in agriculture
91/278		Concerning urban waste water treatment
95/ENV/154		Proposal on integrated pollution prevention and control.

Source: Royal Society of Chemistry, 1996

Table 2.2 - List of EU Directives Related to Waste Management

The European Commission published in 1989, *"A community strategy for waste management"* which identified five guidelines for waste management. The first of these was prevention and minimisation, the second was recycling and reuse; the others were optimisation and final disposal; regulation of transport; and remediation. The need for clean technology and clean production was also emphasised and from this strategy emerged the 1991 framework directive on waste.

This approach was reiterated in 1992 when the Fifth Action Programme on the environment, "Towards Sustainability", was adopted. This built upon Agenda 21, which had emerged from the Rio Summit.

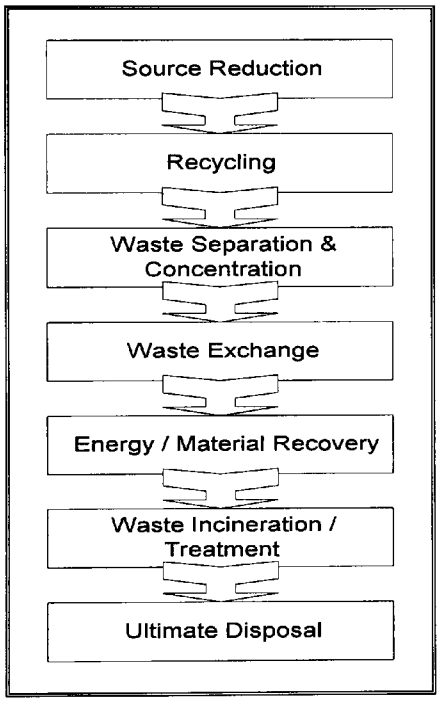
The Packaging Waste Directive of 1994 was intended to contribute to a sustainable waste management strategy within the EU. It requires 50-65% recovery rate for all packaging waste of which 25-45% must be recycled. It is expected that these proportions will be progressively raised over 10 years. Currently, only around 18% of 50m tonnes of the packaging produced annually in the EU is recycled (Royal Society of Chemistry, 1996). The directive also imposes limits on the levels of toxic metals such as cadmium, chromium, lead and mercury permitted in packaging materials.

Electronics waste is regarded as a priority waste stream by the European Commission and, in its draft report, there is a range of recommendations for minimisation, recycling and reuse and diversion from incineration and landfill. Twelve categories of waste are listed and targets are set for prevention (the difference between the amount expected and the amount arising), recovery and disposal. In all cases, prevention rates are set at 5-10% while recovery rates cover a range from 0% (filament type light bulbs) to 90% (cables). These goals are to be met by 2010 and interim targets for 2000 have also been proposed.

Most environmental legislation within the EU is aimed at complying with directives, although some countries may go further than they are obliged or may anticipate future EU requirements (Oliveira and Lloyd, 1998). This has been the case in Germany where an industrial process is not permitted to start up unless there is an acceptable means of disposing of the wastes it produces and a permit to dispose of waste will only be issued if it can be shown that utilising the waste is prohibitively expensive, technically impossible or without a market. Austria already has a requirement for companies employing more than 100 people to prepare a waste management plan. The Netherlands has identified 29 priority waste streams, some of which will be progressively banned from landfill from 1995 onwards. A similar ban already exists in Austria (Price, 1996).

2.3 - The Hierarchy of Waste Management Practices

Options for Waste Management are often arranged in a hierarchical manner to reflect their desirability. In 1984, waste minimisation was first introduced in the US into their Hazardous Solid Waste Amendments to the Resource Conservation and Recovery Act. In 1986, the United States Environmental Protection Agency (US EPA) set a hierarchy of waste management practices shown in Figure 2.1.



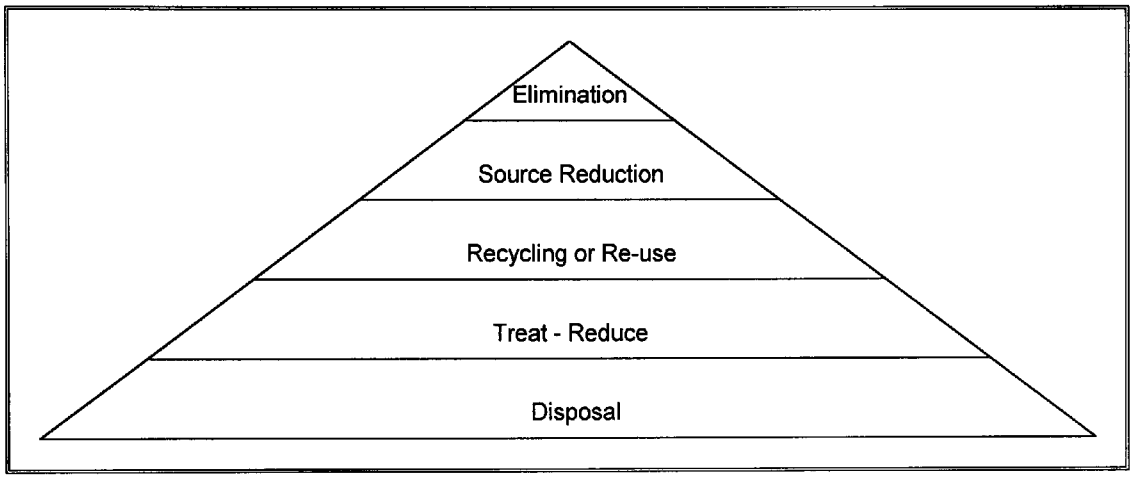
Source: *Connella, P.A. and Rittmeyer, R.W., 1990*

Figure 2.1 - US EPA Waste Management Priority Hierarchy

The "Waste Strategy for England and Wales" (DoE, 1995) also set up a Hierarchy of Waste Management Options. The first priority is waste avoidance (that is, not producing waste in the first place). If the waste must be produced, the quantities should be minimised. Once that has been achieved, the next priority is to maximise recovery, reuse and the recycling of suitable waste materials. Taken together, these three options are called waste prevention.

Once the possibilities for waste prevention have been exhausted, the next priority is to

reduce the volume of residual wastes being passed on for final disposal. Figure 2.2 represents the hierarchy. By coincidence, the volume of each layer in the pyramid is also roughly proportional to the relative quantities of waste currently being managed in most of the countries (Eduljee and Arthur, 1995).



Source: *DoE, 1995*

Figure 2.2 - Waste Management Hierarchy

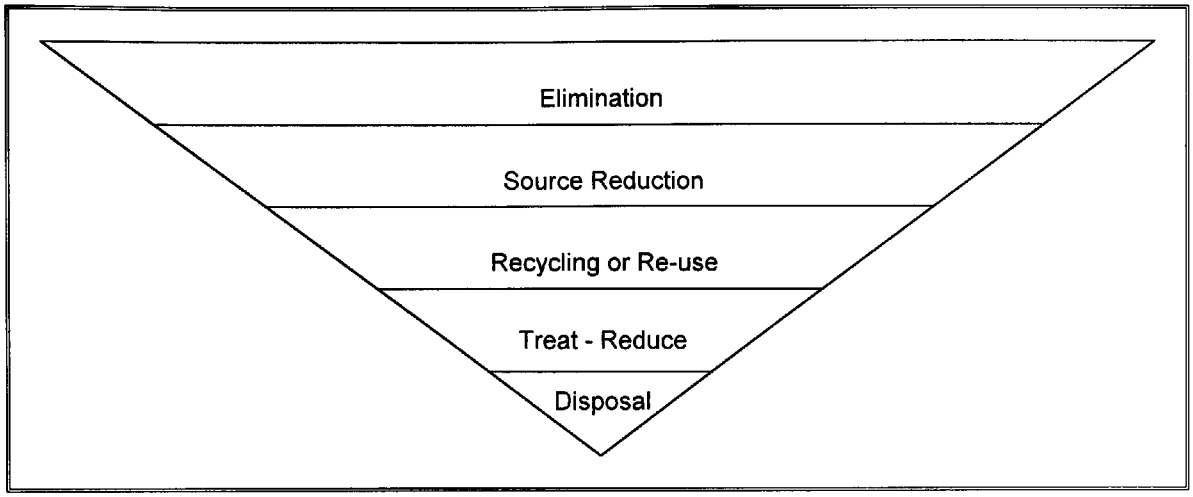
Stage	Description
Elimination	Complete elimination of waste
Source reduction	The avoidance, reduction or elimination of waste, generally within the confines of the production unit, through changes in industrial processes or procedures
Recycling or Re-use	The use, reuse and recycling of wastes for the original or some other purpose such as input material, materials recovery or energy production
Treat – Reduce	The destruction, detoxification, neutralisation, etc. of wastes into less harmful substances
Disposal	The discharge of wastes to air, water or land in properly controlled or safe ways such that compliance is achieved; secure land disposal may involve volume reduction, encapsulation, leachate containment and monitoring techniques.

Source: *Adapted from Crittenden and Kolaczkowski, 1995*

Table 2.3 - Hierarchy of Waste Management practices

Waste minimisation is concerned with the first, second and third levels of the hierarchy. An alternative representation of this hierarchy, defended by a few authors (Eduljee and Arthur,

1995) and the preferred representation of this author is depicted in the figure below.



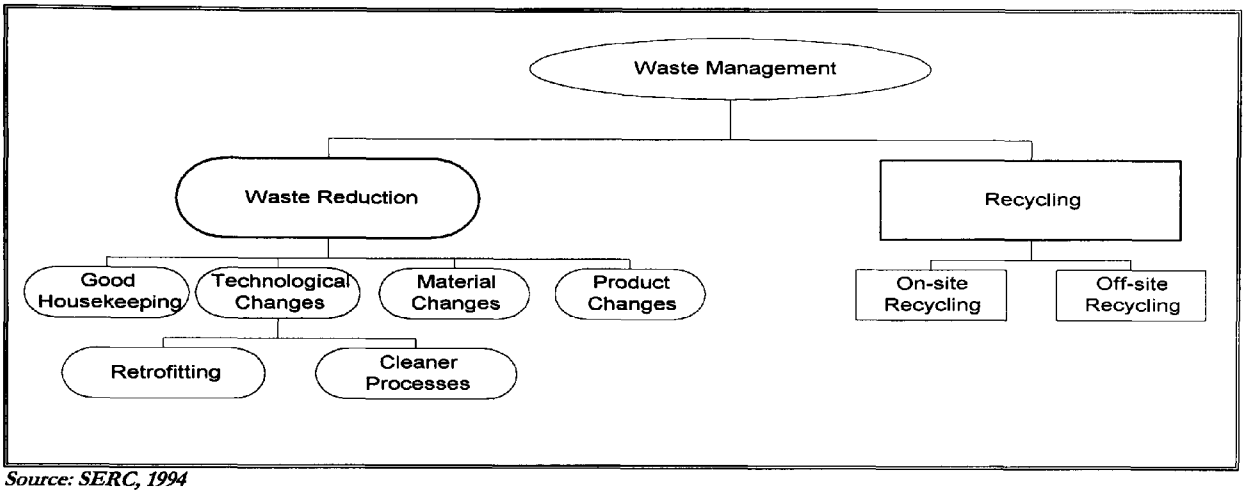
Source: Adapted from Eduljee and Arthur, 1995

Figure 2.3 - Preferred Waste Management Hierarchy

This inverted hierarchy would reflect the relative quantities of waste, which would be desirable, and present a more sustainable waste management strategy.

2.4 - Waste Management Options

An overall summary of options to minimise waste is shown in Figure 2.4. The options fall into two broad categories: waste reduction at source and recycling.



Source: SERC, 1994

Figure 2.4 - Waste Management Options

2.4.2 - Reduction of Waste at Source

Waste reduction at source falls mainly into four categories:

- Good housekeeping – which encompasses good operating practices and sound engineering such as planned maintenance, energy management, etc. These schemes can often be implemented relatively quickly at minimum capital cost and offer good rates of return.

- Technological changes – there are two possible scenarios, retrofitting is related to existing industrial processes and involves making incremental advances. Cleaner processes apply to the design of intrinsically clean technologies, which will provide less waste and use less energy from the outset.

- Input material changes – hazardous materials used as raw materials (e.g. solvents) may be replaced by less hazardous or non-hazardous materials leading to a potential reduction in environmental impact.

- Product changes – product changes are reformulation of final or intermediate

products to reduce the quantity of waste arising from manufacture.

2.4.3 - Recycling

After prevention of waste production and the minimisation of waste, the priority in waste management is re-use or recycling. Recycling is the collection and separation of materials arising from waste, and subsequent processing to produce marketable products (Royal Society of Chemistry, 1996). In a free market situation, there are four basic, linked requirements, which need to be in place before materials recycling can occur successfully (Gascoigne and Ogilvie, 1995). These are:

- There must be a reliable supply of suitable waste materials;
- There must be the means to collect these materials and to transport them to a place where they can be re-processed;
- There must be the means to re-process these materials into suitable raw materials and products; and
- There must be available markets for the raw materials and products produced by the recycling process.

Economic considerations have a major influence on whether these four basic requirements can be achieved. In the real world, a 100% recycling level is unlikely to be an optimal solution in waste management (Gascoigne and Ogilvie, 1995).

2.4.4 - Techniques for Waste Minimisation

In general, there are four techniques for waste minimisation, and these are: inventory management (e.g. materials input), production process modification (e.g. cleaner technologies), volume reduction (e.g. good housekeeping) and recovery (e.g. recycling).

- *Inventory Management* - proper control over raw materials, intermediate products, final products and the associated waste streams, is an important waste reduction technique.

In many cases waste is just out-of-date, off-specification, contaminated or unnecessary raw materials, spill residues, or damaged final products. The cost of disposing of these materials not only includes the cost of the actual disposal but the cost of the lost raw material or product. Methods for controlling inventory range from simple changing in ordering procedures to implementing Just-in-Time (JIT) manufacturing techniques. Purchasing the correct amount of raw materials needed for a production run is one of the keys to proper inventory control. Using JIT techniques the 3M company reduced waste generation by 25 to 65% in their individual plants (Hunter, 1987).

- *Production Process Modification* - Improving the efficiency of a production process can significantly reduce the waste generated at source. Some of the most cost effective reduction techniques are included under this category; many are simple and relatively inexpensive changes to production procedures. Available techniques range from eliminating leaks from existing equipment to new state-of-the-art production equipment which incorporate advanced monitoring.

- *Volume Reduction* - volume reduction includes techniques to separate toxic, hazardous and/or recoverable wastes from the total waste stream. These techniques are usually used to increase recoverability; reduce the volume and thus disposal costs; or increases management options. The available techniques used range from simple segregation of wastes at the source, to complex concentration technology.

- *Recovery* - Recovering wastes can provide a very cost-effective waste management alternative. This technique can help eliminate waste disposal costs, reduce raw material costs, and possibly provide income from a saleable waste. Recovery of wastes is a widely-used practice in many manufacturing processes and can be done on-site or at an off-site facility.

2.5 - Benefits of Waste Minimisation

Waste minimisation benefits will vary according to one's standpoint - an accountant may take a different view from that of a pollution inspector. The benefits will vary as well from scheme to scheme but in most instances they can help satisfy two goals. Firstly, it can assist the attainment of and improvement on regulatory requirements. Secondly, it can provide a company with opportunities to improve profitability by:

- Realising specific economic benefits;
- Reducing liabilities;
- Promoting a positive public image;
- Improving the health and safety of employees; and
- Increasing operating efficiency and hence reducing production costs.

In general, benefits of waste minimisation can be found under the following headings (Price, 1996):

- Environmental Impacts - Any reduction in waste generated, will result in reduced environmental impacts. In the case of solid wastes this usually means a reduction in the amount of material sent to landfill and thus a reduction of the risk of pollution consequent upon this disposal method. Waste minimisation programmes can also reduce discharges of polluting matter to watercourses with consequent reductions in impacts on the aquatic ecosystem. Benefits in terms of reduced air pollution can also be achieved.

- Financial Savings - Whilst the moral behind waste minimisation may be seen as altruistic, there are sound financial motives for prioritising waste minimisation. Regional demonstration projects, described later in this Chapter, such as the Aire & Calder project, and the experiences of companies such as 3M and Dow, have shown that these schemes save money. Unfortunately, the accounting procedures used by

most enterprises do not reveal the true costs of waste generation and disposal, and environmental cost. A questionnaire survey of companies already interested in waste minimisation in North Wales revealed that 54% of them did not know how much they spent on waste disposal, while the Leicester Waste Minimisation Initiative revealed that costs estimated by participating companies as £500,000 per annum were likely to be closer to £13 m per annum - some 4.5% of turnover (Price, 1996). Many of the savings realised through waste minimisation programmes relate to reduction in the consumption of raw materials and energy.

- Energy Conservation - Many waste minimisation schemes result in reductions in energy use either directly, through fuel savings at the plant, or through reduced material and water usage.

- Material Usage - The reductions in materials usage through waste minimisation programmes bring the benefit of savings in the costs of purchased raw materials. There are environmental benefits as well since the extraction, processing and transportation of raw materials involves the use of energy, the generation of pollution and impacts in landscapes.

- Regulatory Reasons - Waste minimisation is beneficial in meeting company's obligations to comply with environmental legislation. Although regulatory reasons are a benefit this is also a main driver for companies to be more proactive in relation to waste minimisation. These and other issues will be covered in Chapter 3, *Environmental Issues and The Pressures for Change.*

- Liability Reduction - Another important reason to reduce waste generation is to avoid potential short and long-term liabilities associated with waste management, transport and disposal.

- Business Opportunities - The OECD has estimated that end-of-pipe and clean-up technology has a world market of around £130bn with an expected growth to £200bn by 2000 (Price, 1996). Companies that fail to see this are missing an opportunity to diversify and be competitive.

- Public Relations - By adopting a waste minimisation scheme, companies will have an improved public image. An additional potential benefit from adopting such schemes is the avoidance of prosecution for pollution offences.

2.6 - Barriers to Waste Minimisation

The barriers for implementing a waste minimisation scheme vary from economic reasons to technical, regulatory and cultural reasons within the organisation (Price, 1996).

The economic barrier can occur when the company feels that it does not have the financial resources or expertise necessary to embark upon an effective waste minimisation programme.

Technical barriers are closely linked with the economic barrier. Sometimes the legislative framework can present a barrier, when planning permission is required for changes in processes and plant.

Resistance to change, a lack of relevant information, and friction among elements within the company represent the cultural barriers. All of these barriers can be easily overcome with the companies understanding the real issues surrounding waste minimisation. The author took into consideration these factors when designing the waste minimisation methodology.

A study published by CEST (as quoted in Price, 1996) showed that 20% of the companies surveyed were concerned about the use of consultants (i.e. for their expertise), and 40% expressed doubts mainly relating to costs or credibility. The study also reported that capital expenditure was a concern, as most people believed that waste minimisation was very capital intensive (i.e. introduction of new clean technologies).

The other obstacles reported by the CEST study included:

- The belief that there was nothing else that could be done to greatly minimise waste;
- Fear of change;
- The belief that waste minimisation is not a high priority;

- Lack of support from top management;
- Lack of expertise and information.

These barriers generally do not apply equally to all organisations. SMEs in particular suffer more from lack of resources (i.e. time and capital).

A survey of members of the Institute of Environmental Management (as quoted in Price, 1996), published in 1995, showed that 74% of respondents felt that lack of management commitment was an obstacle to environmental management. Some 89% of respondents felt that environmental management was becoming more integrated into the overall management strategy, but only 10% of organisations had it fully integrated in their management strategies. The most important barrier was *"conflicting priorities"* since 70% of respondents had other responsibilities besides their environmental role. Lack of commitment was the second barrier and financial resources came third. The main problem with this survey was that it was directed to companies with an environmental manager already in place so denoting that there is already some commitment to environmental issues. The findings are not really applicable to other companies that are at an early stage of environmental awareness.

2.7 - The UK Waste Context

Total UK waste arisings amount to just over 400 million tonnes per year (Gascoigne and Ogilvie, 1995). The Department of the Environment's Digest of Environmental Protection and Water Statistics gives estimates for the annual waste arisings for the UK by sector of activity. A summary is given in Table 2.4. This figure should only be taken as an indication of the approximate value of waste arisings, because of the difference of interpretations of the word *"waste"*, and the reluctance of companies to actually report or even know the extent of their production of waste.

Actually the waste management industry is characterised by a lack of data (MSI, 1995. The majority of statistics available are estimates, and extrapolations on data which were originally estimated several years ago. This is due to the lack of measurement of waste before disposal

(MSI, 1995).

Sector	Annual arisings million tonnes	Date of estimate	Status
Agriculture	80	1991	NC
Mining and quarrying			
Colliery and slate	51	1990	NC
China clay	27	1990	NC
Quarrying	30	1989/90	NC
Sewage sludge	36	1991	PC
Dredged spoils	43	1991	PC
Household	20	-	C
Commercial	15	-	C
Demolition & construction	32	1990	C
Industrial			
Blast furnace and steel slag	6	1990	C
Power station	13	1990	C
Other	50	-	C
Total	402	-	-

NC = not classed as a controlled waste under the terms of the Environmental Protection Act (Controlled Waste Regulations) 1992; PC = sewage sludge is classed as a controlled waste as defined in the EPA (CWR) 1992 except when disposed of on agricultural land or within the cartilage of the sewage works at which it arises; dredged spoils are classed as a controlled waste when licensed for disposal under the Food and Environmental Protection Act. C = controlled wastes under the terms of EPA (CWR) 1992

Source: Gascoine and Ogilvie (1995) Recycling Waste Materials: Opportunities and Barriers

Table 2.4 - Estimated Total Annual UK Waste Arisings

According to MSI (1995) there was a 2% increase, from 1990 to 1994, in the quantity of solid waste arisings, nevertheless MSI (1995) believe that the overall trend in many sectors is moving towards lower waste arisings. This is due to the introduction of tighter regulation.

The recession at the beginning of early 1990s encouraged many businesses to reduce their waste in order to lower their costs by minimising the amount needed for disposal and reclaiming materials for recycling and reuse. However, the subsequent recovery of the economy is believed to have resulted in marginal growth in the volume of solid waste arisings in the UK (MSI, 1995).

Industrial waste is the largest sector of controlled waste arisings in the UK representing some 43% of the waste available to private contractors in 1994 (MSI, 1995). It is generated by a large variety of industrial activities and includes waste such as packaging, containers and raw materials. The volume of industrial waste produced fell from 50 million tonnes in 1990 to 48

million tonnes in 1992. This reflected the increase of waste reduction schemes in order to reduce raw material and disposal costs. Table 2.5 represents the industrial waste arisings in the UK from 1990 until 1994.

Year	Waste Arising Million Tonnes	% Change
1990	50	n/a
1991	49	- 2%
1992	48	- 2%
1993	49	+ 2%
1994	51	+ 4%

Source: *MSI, 1995*

Table 2.5 - Industrial Waste Arisings in the UK , 1990-94 (million tonnes)

The change in the industrial sector away from the heavy engineering to light engineering and services has also had a major effect on the amount of waste generated in the UK, as light industries typically produce less waste. Nevertheless, the total volume of waste arisings is expected to increase as the economy continues to grow. The forecast of MSI (1995) is that the amount of waste arisings should stabilise by the year 2000, with an increasing amount being reused or recycled.

The data compiled by MSI (1995) basically represent the volume of waste that has been discarded. What it does not take into consideration are the costs associated with the generation and disposal of the waste arisings.

In 1995 a study was made which examined waste awareness and practices within seven sectors of British Industry (Biffa Waste Services, 1995). Seven universities that formed the British Waste Management Forum carried out the research. One of the objectives of this study was to find out if companies measured their waste costs and whether they had waste minimisation programmes in place. The results revealed that 44% of companies overall do not know how much they spend on waste and of those that do, only 44% include the purchase costs of wasted raw materials as well as contractors' waste disposal charges. Some 54% of companies do not have a proper environmental management system operating while 46% have no waste minimisation policy, although just over half of those who do not have such a programme plan to implement one. Financial factors were cited as the main reason for

recycling by most (64%) of the companies (Biffa Waste Services, 1995).

The results obtained by Biffa represent some improvement on the results of a survey carried out by Orr & Boss in 1991 (quoted in Price, 1996), where only 28% of companies could estimate their waste costs and 26% regarded waste minimisation as central to an environmental policy.

2.8 - Supporting Tools for *Waste Minimisation*

Several techniques involving computation, simulation, graphical construction and the use of keywords have been developed or adapted to enable process engineering waste minimisation studies to be carried out.

2.8.1 - Simulation

Simulation of complex processes using flowsheeting packages or bespoke programs can be used to make assessments of the potential for any flowsheet to lead to the generation of waste and hence aid the study of waste minimisation. Hopper *et al* (1993) provide a case study of the effects of choosing different reactor types and the optimisation of reaction conditions on the formation of unwanted by-products in an acrylonitrile process.

2.8.2 - Graphical Mass Balance

In many processes, waste materials can arise from a variety of sources including, for example, incomplete conversion of the feed, use of an impure feed and undesirable side reactions. When these sources occur simultaneously, reducing the generation of waste becomes a non-trivial task. The reactor is central to the generation of waste and so separators are often situated directly after it in order to remove various parts from the product.

The graphical mass balance concept developed by Flower *et al* (1992) consists of three basic parts: the reaction box (R-Box), the separation box (S-Box) and the R-S Box combination. The R-S Box comprises the graphical mass balance. Each part consists of a diagram in which

component mass flow rates are plotted against mass fractions for a specific process operation. These are used to represent the governing mass balances visually and manipulate them with the objective of reducing the waste generated.

The method lends itself to software development in which fast interactive manipulation of the mass balance becomes possible. Mass balance calculations can be made in the background and the computer screen updated as the changes are made.

2.8.3 - Environmental Optimisation (ENVOP)

The Hazop technique (described in Crittenden and Kolaczkowski, 1995) is a well-established method for reviewing the safety of process plant designs and their modifications. Significant modification of the Hazop technique using environmentally-conditioned keywords can provide an effective way of systematically reviewing any process from the point of view of reducing the effluents that it generates.

The method developed by BP and Costain, and described by Potter and Isalski (1992) is based on formal review meetings. At these meetings, a series of environmental objectives are set. A formal environmental optimisation (ENVOP) review meeting follows, using appropriate keywords during which minutes of allocated actions are taken. Economic analysis is then applied to narrow down the number of options that potentially arise from the minutes. The method can in theory be applied to any chemical and/or separation process, whether new or existing. ENVOP can therefore be used to aid retrofitting and design of cleaner processes.

2.8.4 - Life Cycle Analysis (LCA)

Environmental life cycle analysis or assessment (LCA), and in particular comparative LCA, is a powerful tool for reviewing the impacts that alternative products or processes have on the environment. It aims to quantify all effects from the energy used and environmental disruption caused when the materials used to manufacture the product are extracted. This includes the emissions generated and materials used during processing, manufacture and use, to the impact of disposal of the product as waste at the end of its useful life. Such analyses

are used in the awarding of eco-labels and can be used to determine which of a number of competing products has the least impact on the environment. In essence, LCA is concerned with the measurements of inputs and outputs of any system whose function can be defined. It lends itself particularly to the assessment of environmental costs in the production of goods and the provision of services. A critical factor in LCA is the definition of the system boundary within each all consumption's and emissions are evaluated, and outside which any consumption's and emissions are considered to be part of the general environment in which the system operates.

Despite the great attention that LCA has received from many researchers over the last twenty years, it still remains a technique that enjoys relatively little practical application. Recent criticism of the conventional approach to LCA has come from a group of workers at the US Carnegie Mellon University (quoted in Price, 1996). These workers use an economic input-output approach to calculate the environmental consequences of a given increase in consumption of a product, considering both direct and indirect discharges of pollutants on an emission-per-dollar basis. Most LCAs, which follow the model developed by the Society for Environmental Toxicology and Chemistry (SETAC) would omit about half the total releases relating to a product, mainly because of the boundaries drawn within the model.

2.8.5 - Waste Management Modelling

Optimising the waste system to reduce environmental impacts or economic costs requires that these impacts and costs be predicted, hence the need to model waste management systems. Modelling of waste management is far from a new idea. Clark (1978) reviewed the use of modelling techniques then available to optimise collection methods, predict the most efficient collection routes and define the optimal locations for waste disposal facilities. Such models concentrated on the detailed mechanics of individual processes within the waste system. Other models have attempted to take a broader view and have compared alternative waste disposal strategies from an economic perspective (e.g. Greenberg *et al*, 1976).

More recently, detailed models have been developed to assess the economics of materials recovery for recycling, and some of its environmental impacts (Boustead, 1992), as well as

broader models including costs, public acceptance, environmental impact and ease of operation and maintenance of waste disposal alternatives (Sushil, 1990). The Sushil model attempts to predict both the environmental impacts and economic costs, since both are crucial for an integrated waste management system.

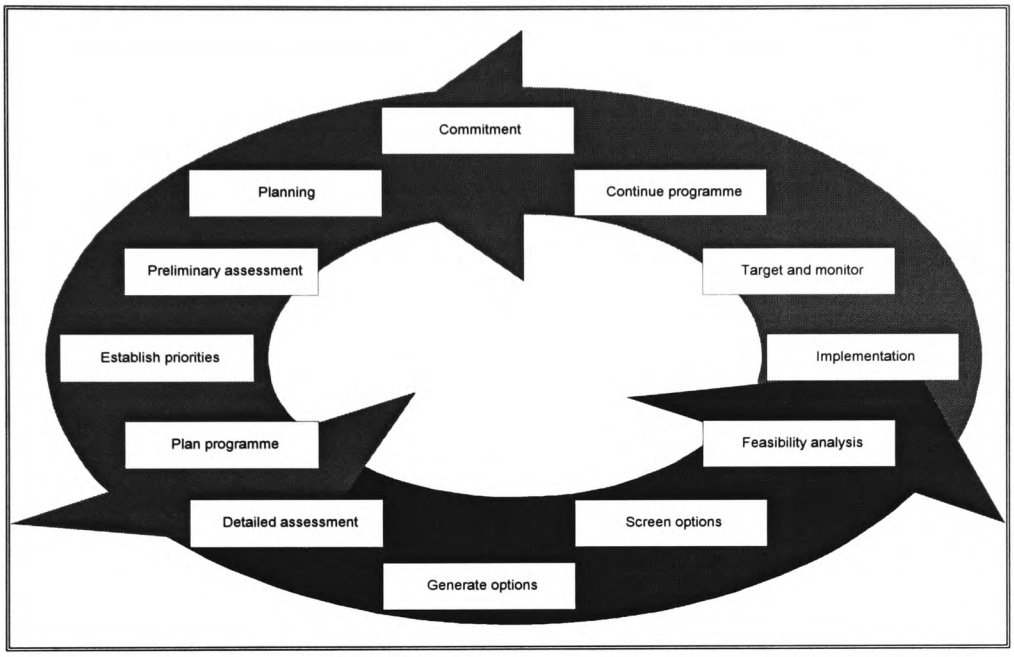
2.9 - Waste Minimisation Methodologies

Waste minimisation schemes vary, and the implementation will differ according to the company that will implement it. For a waste minimisation scheme to be successful it must be approached in a systematic way, and there are various protocols for this (Price, 1996).

One of the first waste minimisation schemes was devised by the US EPA (1988) and directed to hazardous waste. Figure 2.5 outlines this methodology.

The US EPA (1988) methodology starts with the commitment from top management to reduce waste. The second step is planning and organisation. In the assessment phase, data is collected and reviewed, targets for assessment are selected and prioritised, assessment teams are chosen, site inspections made and options generated.

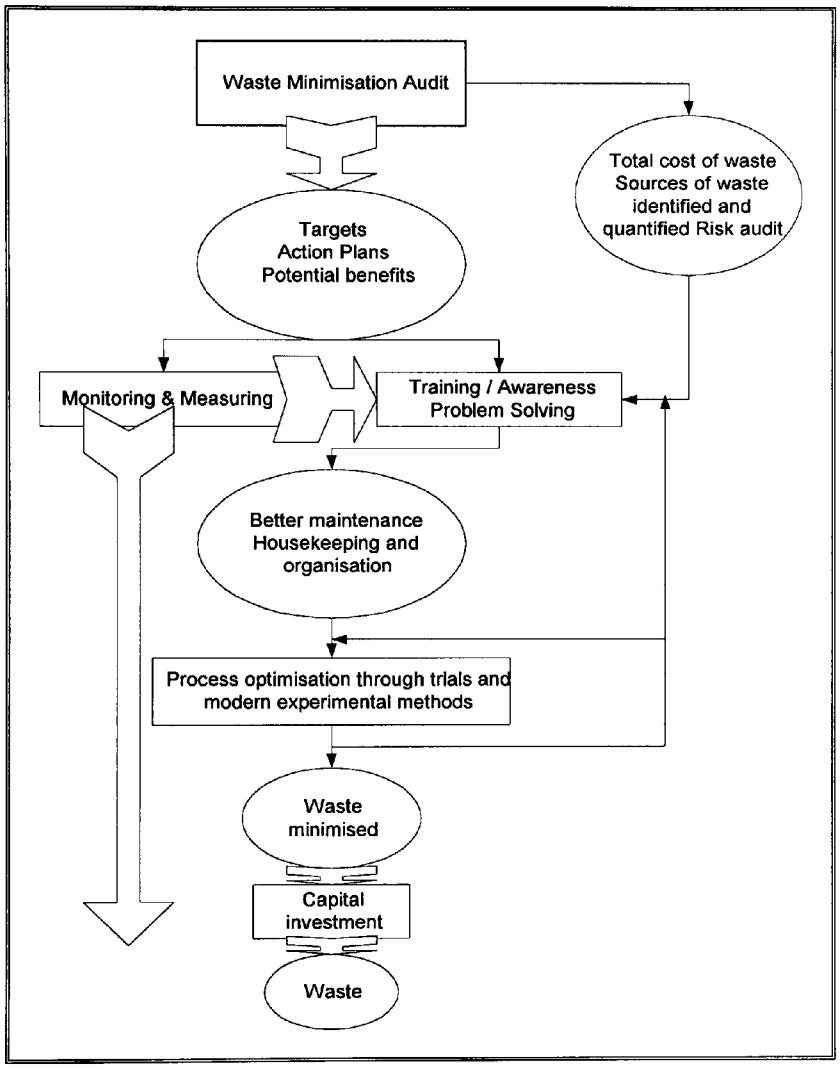
The feasibility analysis phase comprises technical and economic evaluations followed by the selection of options for implementation. The chosen schemes are then implemented and evaluated. This procedure has been refined and modified in a variety of projects (Price, 1996).



Source: ***Adapted from US EPA, 1988***

Figure 2.5 - US EPA Waste Minimisation Methodology

Another approach used to develop a waste minimisation strategy is the Orr & Boss (1991) methodology (see Figure 2.6).

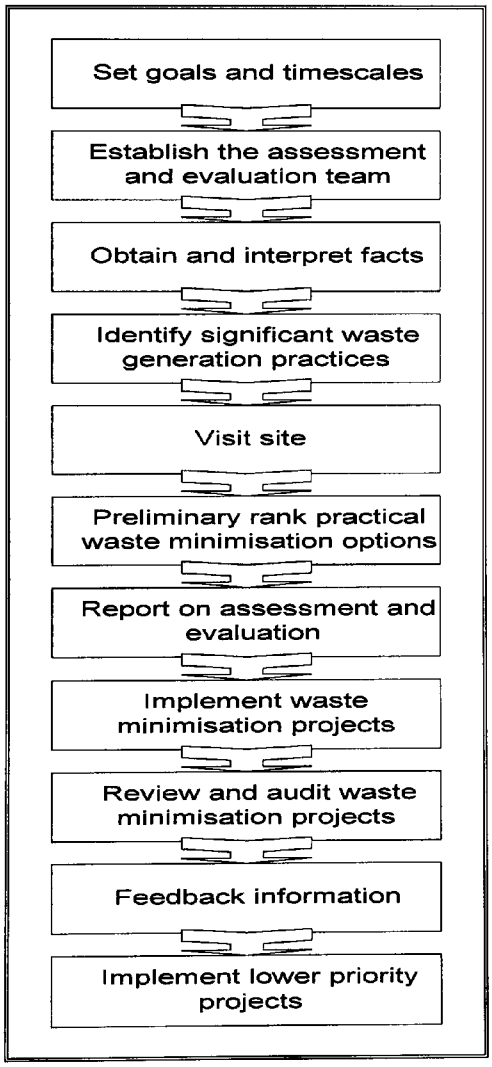


Source: Orr & Boss, 1991

Figure 2.6 - The Orr & Boss Methodology

The Cheshire based consultants Orr & Boss (1991) utilise the structured approach depicted above to develop a comprehensive waste minimisation strategy. They start by undertaking a waste minimisation audit that allows for quantifying the total cost of waste and its sources. This audit forms the basis for planning for action and setting targets. At this stage, training and awareness programmes are established and corrective action is taken at two levels: better maintenance and housekeeping; and process optimisation.

Crittenden and Kolaczkowski (1995), provide another methodology in the Institution of Chemical Engineers Waste Minimisation guide. Their methodology (see figure 2.7) was tailored for all process-engineering companies, although the author argues that they can be tailored to meet local needs. For example, a SME may be able to dispense with steps concerned with the preliminary ranking of options and the implementation of lower priority projects, since their waste generation activities might only encompass the implementation of one or two projects.



Source: Crittenden and Kolaczowski, 1995

Figure 2.7 - Methodology of Waste Minimisation

A common issue between the different methodologies and the driver for waste minimisation to go forward is that the sequence of the different stages is not a fixed one - information schemes may be implemented in parallel with common-sense modifications. Starting a programme with cheap, common sense measures generates enthusiasm in the workforce and can help secure support from senior management for later, more capital intensive changes if necessary.

According to Price (1996) whichever methodology is used, some basic principles apply to almost all schemes:

- A structured and methodical approach;
- Reliable and comprehensive data must be obtained;
- Support from top management is crucial; and
- The workforce should be involved in all aspects of the project.

2.10 - Waste Minimisation Projects

The benefits of waste minimisation have already been demonstrated within the UK by the projects sponsored by government and industry. After a year of the Aire and Calder Project in Yorkshire, the eleven companies involved had achieved £2.2 million of savings per year (Johnston, 1995). The fourteen companies involved in the more recent Catalyst Project in the North West of England, have identified potential annual savings of £8.9 millions through various waste minimisation techniques (March Consulting Group, 1994). In these projects, the opportunities for waste minimisation were identified by the staff, with companies using the expertise they have within their organisations. The people who produce waste best identify reductions in waste that can be made.

The success of these projects has generated a great deal of interest. In 1994, the Department of Trade and Industry (DTI) sponsored eight feasibility studies, four of which have now matured into full projects. Her Majesty's Inspectorate of Pollution (HMIP), through a

contract with the Centre for Exploitation of Science and Technology (CEST) and other bodies, have also initiated regional ventures.

2.10.1 - The Landskrona and PRISMA schemes

The first regional initiative on waste minimisation in Europe was started in 1987 in the Landskrona area of Sweden as an initiative of the University of Lund's environmental research organisations TEM. The aim of the project was to improve health and safety and environmental performance in seven SMEs in the graphics, chemical and metalworking industries.

In Holland, there was the PRISMA scheme which looked at waste minimisation and clean technology in 12 companies around Rotterdam and Amsterdam from 1988 to 1990. During the project 134 potentially feasible waste minimisation measures were found and of those implemented some 42% involved no capital costs with an additional 30% having a payback time of less than two years (Price, 1996).

2.11 - Summary

This Chapter described the issues surrounding waste minimisation, such as the definitions of waste, tools and techniques, different methodologies and waste minimisation in practice. It was found that overall waste minimisation is clearly a desirable objective both on economic and environmental grounds with substantial benefits to be gained by companies making a commitment in this direction.

Chapter 3 - Environmental Issues And Pressures for Change

3.1 - Introduction

In this chapter the author describes why it is important to look at SMEs for improving environmental performance, and attempts to provide an overview of the most important pressures on companies for action.

Incentives to embark upon waste minimisation programmes are coming from two areas: the growing awareness of the economic benefits to be obtained through improved efficiency in materials and energy use; and legislative pressures aimed at securing environmental improvements which will, directly or indirectly, make it more difficult or more expensive for companies to generate and dispose of waste materials in a less than cautious manner.

From an analysis of a number of researchers (Eden, 1996, Curran and Blackburn, 1994, Morgan, 1997, Malandrini, 1999), the author concludes that Small and Medium-Sized Enterprises (SMEs) collectively constitute the biggest source of pollution but generally feel that they do not have the expertise in-house to tackle waste minimisation issues. Furthermore, their capital resources are likely to be tight, making the employment of external consultants expensive. Additionally, any major capital expenditure by SMEs is unlikely (Curran and Blackburn, 1994). However, the replacement or refurbishment of old equipment, which would have been necessary anyway, does provide the opportunity for more drastic waste minimisation measures to be introduced.

Several schemes for assisting smaller companies are in existence, as described in the previous Chapter. The financial assistance provided by the EU is vital for such schemes. The author examines how to make such schemes for SMEs sustainable in the long term.

3.2 - Small and Medium-Sized Enterprises in Perspective

SMEs are becoming increasingly important in terms of employment, wealth creation and technology development (Malandrini, 1999). Small and medium-sized businesses according to Morgan (1997) are possibly the most important sector in the UK in terms of economic growth. It has been recognised by various authors (Curran and Blackburn, 1994, Morgan,

1997, Malandrini, 1999) that the economies of countries within the European Union are based on enterprises of less than five hundred employees. In the United Kingdom, over 96% of organisations employ less than twenty people (DTI, 1994). Before an analysis of any kind is carried out, it is important to try to understand what a small and medium-sized business is.

The SME sector can be broken down into various subcategories, although there is no standard definition and data are currently collected for a number of different size bands (Morgan, 1997). They may be based on quantitative criteria (e.g. employee numbers, turnover), qualitative criteria (e.g. nature of ownership, management structure, decision making) or some combination of these; and they may be universally applicable to all sectors or differentiated by sector (Bolton, 1971, Curran and Blackburn, 1994). One useful criteria, and the one used in this research, is the widely-accepted Eurostat definition (as quoted in Morgan, 1997):

- Micro 0 - 9 employees
- Small 10 - 99 employees
- Medium 100 - 249 employees

3.2.1 - A profile of SMEs in the UK

At the time of the Bolton Report (1971), there were at least 1.25 million small and medium-sized enterprises in the United Kingdom (Stanworth, 1991), they gave employment to some 6 million people or about 25 per cent of the employment population, and are responsible for nearly 20 per cent of the gross national product (GNP).

The situation of SMEs today is somewhat different. Stanworth (1991) the chairman of the Small Business Research Trust states *"since the Bolton report of 1971, the small business community has undergone dramatic change in some areas and relatively little in others"*. Also, Stanworth (1991) sets out several issues if the small business sector is to achieve true potential in terms of wealth generation. They are:

- The importance of the small business community to the contribution to the United Kingdom economy;

- The need to improve our understanding of the external pressures (e.g. competition, legislation, customers) that face small businesses;

- The need to improve our understanding of the internal constraints (e.g. lack of in-house expertise, tight budgets) faced by the small businesses on a day-to-day basis; and

- The need for the government to ensure a *"level playing field"* in terms of regulatory burden, competition, and the costs and availability for finance.

Some of the changes that are evidenced by statistics are that, since 1971, the number of SMEs has increased (DTI, 1994). In 1979, there were 1.8 million and, by 1989, 2.9 million. By 1991, it had fallen back to 2.7 million. The DTI (1994) reported that, in 1994, 96% of all firms employ fewer than 20 people, with over 99% fewer than 100 employees. The trend towards larger businesses to accommodate economies of scale had been reversed.

Daly and McCann (1992) carried out a survey, on behalf of the Department of Employment, which included the distribution of SMEs in terms of employment size. The key findings of the survey were stated as follows:

- At the end of 1989, there were an estimated three million firms in the United Kingdom;

- Over 95% of all UK businesses employ fewer than 20 people which represents 35% of total employment outside central and local government;

- The overall number of businesses in the United Kingdom rose by two thirds between 1979 and 1989 - an average of nearly 500 additional firms every working day.

Twenty years on from the Bolton Report, Stanworth (1991) asserts that the problems facing SMEs quoted in the Bolton Report (1971), (e.g. difficulty getting financial support, training and advice, regulatory burden), are largely the same. Further, Stanworth (1991) concludes that

SMEs will still face the same problems as an inevitable consequence of their small scale. Small business owners are acutely subject to time pressures and can be easily criticised for the lack of specialised knowledge which is available within the more elaborate structure of the larger firm. Lack of time can explain the low tolerance of some small business owners regarding new bureaucratic requirements.

Low tolerance of burdens should be considered as a very important point in the context of SMEs and their existing management systems and might, amongst other reasons, explain why certification to the BS5750/ISO9000 series of standards is seen in the same light.

3.2.2 - Contribution of Small and Medium-Sized Enterprises to Economic Growth and Competitiveness

The contribution of SMEs to the UK and Welsh economies increased significantly during the period 1980 to 1995 (Morgan, 1997). In particular:

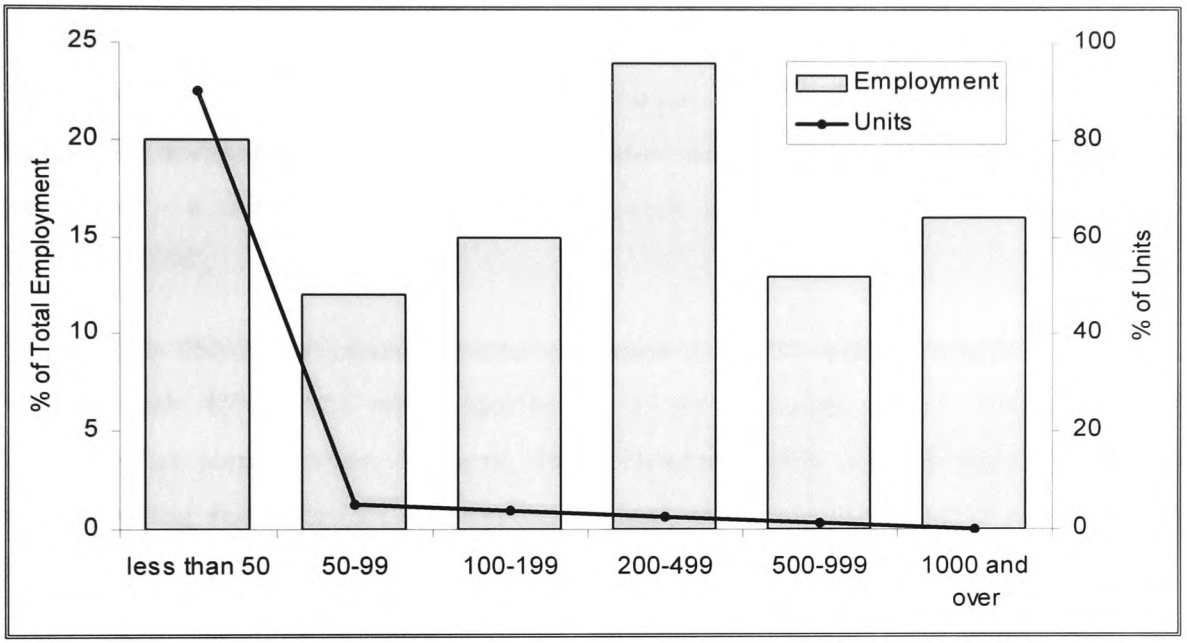
- The total number of SMEs increased substantially - from 2.3m to 3.5m in the UK and from 50k to 75k in Wales;
- The share of manufacturing GDP produced by SMEs rose from 25% to 45%; and
- Their share of manufacturing employment rose to around 50%.

Evidence in the UK and in Wales reveals that small firms are the most important source of new job generation (Morgan, 1997).

The chart shown below (Figure 3.1) shows the distribution of Welsh manufacturing firms by size of company. As seen on the graph, firms with less than 500 employees account for 99% of all manufacturing units in Wales and 71% of total manufacturing employment. The chart also shows that almost 50% of manufacturing employment is concentrated in firms employing less than 200 persons.

Other figures from the Welsh Office (Morgan, 1997) indicate that between 1990 and 1995, 55% of the Welsh manufacturing firms employing between 10 and 50 employees had

increased their employment levels, with the total number of jobs within these companies increasing by 36%.



Source: Morgan (1997)

Figure 3.1 - Analysis of Welsh Manufacturing Units by Employment Size Band, 1994

In addition to this evidence that SMEs are vitally important for employment creation, there are also signs that a substantial proportion of new job creation is concentrated in a few, fast growing, *"young"* firms (Storey, 1994), e.g. firms set up in the 1980s showed the strongest employment growth in the 1990s, but they were also the firms with the lowest chances of survival.

In contrast to larger firms, the smaller and more intimate nature of SMEs coupled with ownership or centralised managerial responsibility within the company means that there is a more dynamic and entrepreneurial style of management, management is closer to the shop floor, internal communication is characteristically open leading to greater consistency of internal modifications and actions and a majority of shop floor employees have a better understanding of external market factors (Storey, 1994, Riat, 1996).

3.2.3 - The Future for SMEs

According to a finding by MIT researcher David Birch (as quoted in Howard, 1990), small and medium-sized companies of fewer than 100 employees were responsible for as many as eight out of ten new jobs. When many big companies were slow to respond to shifts in technology and markets, small and medium-sized companies were on the cutting edge of innovation - a trend symbolised by the high-tech start-up in California's Silicon Valley (Howard, 1990).

The roughly 355,000 US manufacturers with fewer than 500 employees are responsible for approximately 46% of the value-added in the US manufactured products (Howard, 1990). This is what some authors (Morgan, 1997, Howard, 1990) argue is the *"base"* of the manufacturing economy. To an important extent, the competitiveness of major US and European manufacturing corporations depends on these small suppliers.

The findings of *"The Emergence of Small Enterprise"* (as quoted in Howard, 1990), a major international study of small businesses were that, for most of this century, the size of the small business sector was shrinking throughout the industrialised world. Around 1970, that trend began to reverse when small businesses employment share began to grow slightly. Another shift observed by the study (as quoted in Howard, 1990), was that the key unit of production stopped being the individual company to become a decentralised network of companies. Sometimes these networks consisted of vertical links tying small suppliers to large final assemblers. In other cases, the links were horizontal - binding together a number of small companies that wished to collaborate. Too small to do their own research and development or worker training, these small companies depended heavily upon outside institutions - universities, trade associations and government agencies.

The predominance of SMEs in the Japanese economy is also interesting to investigate. About 75% of manufacturing employment in Japan (Howard, 1990), is in small and medium-sized sector (in contrast to about 35% in the US).

In their book *"The Machine that Changed the World"*, Womack *et al* (1990) described that in manufacturing industries in Japan, production is organised according to the supplier-group

system - a network of large and small companies arranged in a pyramid. At the top, a large *"parent"* company is responsible for final assembly. It deals with the next tier of smaller companies who make major components and subassemblies. These first-tier suppliers then manage relations with a more numerous second tier of manufacturing specialists. These companies in turn work with a third and sometimes even a fourth tier of smaller and smaller companies specialising in increasingly narrow tasks.

Unlike traditional customer-supplier relations, Japanese suppliers have long-term relationships with their customers. According to a survey of Japanese subcontractors, 68% of the respondents had never changed their parent, and 53% had been doing business with the same parent for 15 years or more. Even more importantly, Japanese suppliers and customers constantly share detailed information about production costs and techniques (Howard, 1990). Japanese companies both pressure and support their suppliers. It is precisely this combination of competition and co-operation that makes for a responsive, high quality, and increasingly dynamic industrial system. The supplier-group system allows the lead company to stay lean and focused.

Womack *et al* (1990), argue that, in the US auto industry, *"the reforms made to date have involved pushing the traditional mass-supply system to its limits under pressure, rather than fundamentally changing the way the system works"*. The lessons gathered from the observations made are to forge close relationships with customers, suppliers, and other partners, in order to maintain a creative tension between competition and co-operation. The focus should be on continual innovation. The author considers this point crucial for the development and implementation of a waste minimisation methodology (described in Chapter 5), and will pursue this in more detail in the analysis of the crucial success factors for waste minimisation (refer to Chapter 6).

3.3 - Pressures on Businesses for Environmental Change

In her book *"Environmental Issues and Business Implications of a Changing Agenda"*, Sally Eden (1996) identified four specific external sources of pressure for environmental change: legislation; consumers; NGOs; and other business sectors such as insurance, investors and suppliers. She based her choice on an analysis of a range of surveys. The findings of these

surveys were that legislation is the main force for environmental change and the percentages are presented in the Tables 3.1 and 3.2 below.

Areas Analysed	1994 (%)	1995 (%)
UK legislation	90	84
Corporate environmental policies	62	59
European legislation	57	68
Consumers	40	
Cost Savings	16	47
Environmental NGOs	9	
New Business Opportunities		26

Source: Eden, 1996

Table 3.1 - Environmental Change Surveys

Another survey of over 500 company's directors for *Director* magazine for the Institute of Directors (Eden, 1996) was undertaken in 1990 (please refer to Table 3.2 below). The survey selected a list of pressures on directors to develop an environmental policy, namely: employees, customers, suppliers, public opinion, and family. As Eden (1996), indicates in her book this survey did not consider legislation or NGOs, which we have seen, were identified as major importance in other surveys of this kind. This view of pressures is then more restricted. The results are shown in the Table 3.2 below.

Pressure source	All Sectors	Manufacturing	Non-Manufacturing
Public opinion	50%	52%	50%
Family	48%	39%	53%
Employees	25%	21%	28%
Customers	21%	26%	18%
Suppliers	7%	9%	5%

Source: Eden, 1996

Table 3.2 - Sources of Pressure on Companies for Environmental Change

A survey (refer to table 3.3) undertaken, in the UK, by the PA Consulting Group for the CBI questioned 250 large companies, about the pressures they felt for the need for environmental change (Eden, 1996). Here the sources of pressure are divided between influences on behaviour and on performance, the latter dominated by legislation and internal ethics.

Drivers of environmental performance (most significant first)	Influences on company behaviour (most significant first)
Government legislation	Local authorities
Corporate social responsibility	Local community
EU legislation	National pressure groups
Customers	Media
Commercial pressures	Local pressure groups
Public opinion	
Conscience	

Source: *Adapted from PA Consulting Group survey for CBI, 1990 by Eden, 1996*

Table 3.3 - Drivers and Influences on Environmental Performance

Roome (1992) assumed that if legislation is driven by public perception in the immediate term and only more slowly by scientific developments, then legislation is not a principle or explicit part of the pressure but is a consequence of other pressures. Roome (1992) suggests that small and medium-sized companies respond more quickly to change in public perception than to change in the scientific understanding of environmental issues, which only summons a slow response, but in either case he still characterises company strategies as reactive.

The problem with such surveys is that they do not take into account that different companies from different sectors of activities and of different sizes will be affected by different pressures. For many retailers, legislation has been less forceful than public opinion, prompting them to review their environmental procedures. For manufacturing SMEs, legislation is far greater in influence (please refer to the findings of a survey undertaken by the author presented in Chapter 5).

Since this research is directed to SMEs, each of the factors considered as determinant for environmental change will be considered from a SME point of view. According to Eden (1996), there are four *"umbrella"* pressures (termed as such because they group several issues). These are: - *Legislation*, clearly important, especially in the EU context. *Consumers*, which link to public opinion. *NGOs*, cited as indirectly influencing legislators and public opinion. *Other businesses*, are noted in the surveys and are becoming increasingly important as environmental investment and insurance begin to appreciate the implications of environmental legislation.

3.3.2 - Legislation

There is a full account of legislation covered in the previous chapter and it is easy to see why there is a general feeling that the most fundamental pressure for business environmental change to be legislation. However, regulation and enforcement depend strongly on the government's disposition towards environmental reforms (Eden, 1996). The pressures should not be considered separately, i.e. NGOs focus public opinion, which can feed political action and regulation and also be influenced by them in turn.

Over the five-year period 1992-1997, at least twenty surveys have been reported which address the response of SMEs in Britain to the environment and environmental management (Eden, 1996). The focus on SMEs has reflected recognition of their importance in terms of business activity (38% of all businesses are companies in the 10 - 249 employee range, Petts *et al*, 1999) and that their activity could have a significant cumulative (not necessarily individual) environmental impact (KPMG, 1997).

A common theme to emerge is that compliance with legislation is a key motivating factor behind environmental performance. Managers of SMEs feel that they lack time, human resources and finance to actually be concerned with the environment.

Over the last decade, legislation aiming to reduce and control the environmental impact of businesses has increased substantially. All companies, large or small, are responsible for the negative environmental impacts of their operations. Moreover, pressure on smaller companies to improve their environmental performance is increasing as larger companies realise the benefits and need for environmental management and require similar standards for their suppliers.

All companies, large or small, in their processes cause environmental impacts on air, water, land or other. Table 3.4 below shows which legislation affect the different impacts.

Legislation	Air	Water	Liquid Waste	Solid Waste	Land	Packaging	Noise
IPC	✓	✓	✓	✓	✓		
Local Air Pollution Control	✓						
Clean Air Act	✓						
Water Industry Act		✓					
Water Resources Act		✓					
Duty of Care			✓	✓	✓	✓	
Special Waste Regulations			✓	✓	✓	✓	
Packaging Waste Regulations						✓	
Contaminated Land					✓		
Statutory Nuisance	✓				✓		✓

Source: *Connell, et al (1998) Mapping the Maze*

Table 3.4 - Environmental Impacts Tackled by Legislation

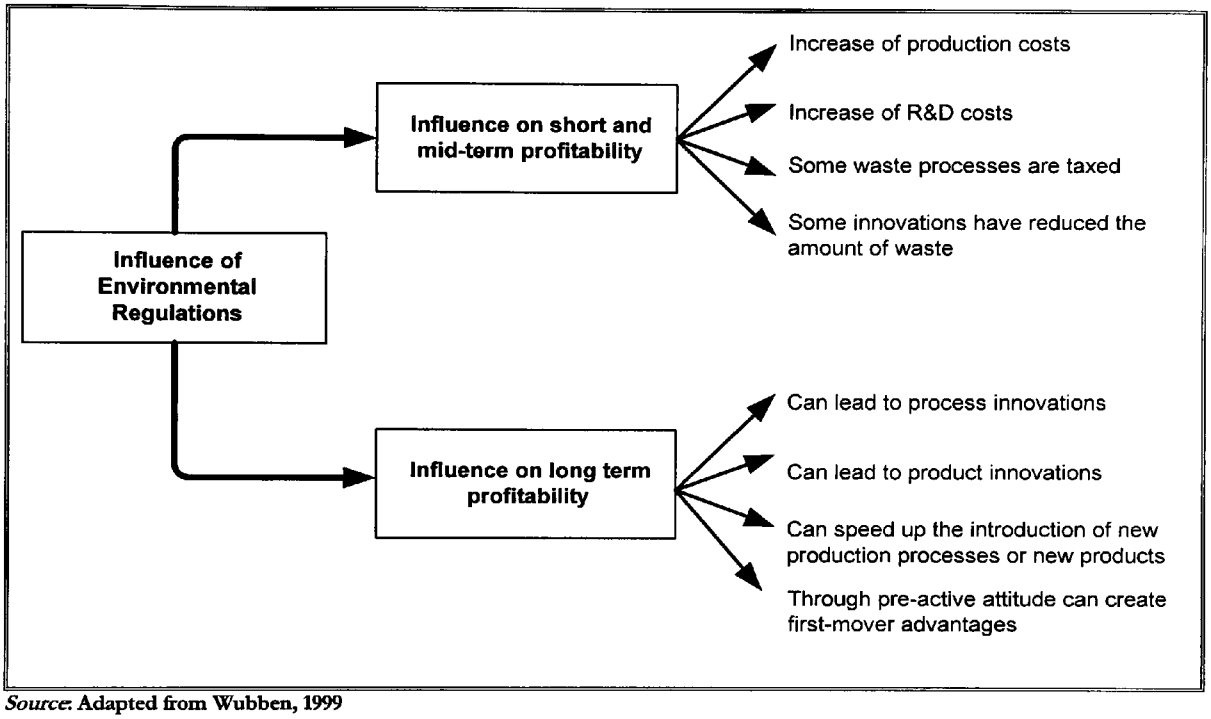
On the positive side, environmental legislation can provide a useful focus for initiating business improvements that can result in increased efficiency at the same time as benefiting the environment. For example, ensuring that in-house waste management practices comply with legislation can enable the identification of unnecessary waste.

Politics, the business community, special interest groups and the general public differ widely in their views on the impact of environmental legislation or the way companies do business. Is environmental legislation leading to a focus on high-tech innovations and an increase in resource productivity and is it thus a creator of competitive advantages for first movers? Or does environmental legislation merely obstruct free competition, impose costs, and reduce productivity growth, thereby creating trade distortions and competitive disadvantages? (Wubben, 1999)

Several interest groups, a number of corporations and various scientists are of the view that environmental legislation has a negative influence on trade flows and competitiveness, resulting in the migration of polluting industries to countries where environmental legislation is not as strict (Wubben, 1999).

On the other hand, the European Commission claims (Eden, 1996) that environmental policies improve resource productivity, employment and the competitiveness of companies. To add to this view, countries with the strictest environmental standards, e.g. the Netherlands

and Germany, do not show any sign of being uncompetitive. These two different views are generated from the conflict between the short and the long-term results. This idea is best explored on Figure 3.2 below.



Source: **Adapted from Wubben, 1999**

Figure 3.2 - Influence of Environmental Regulations on Short and Long-term Profitability

Managers, especially from SMEs, are threatened by the cost implications of environmental legislation so their first reaction is to adopt end-of-pipe solutions rather than being proactive and innovative. From figure 3.2 we can see that there are elevated costs in the short and mid-term, but, if opportunities are taken, in the long term it may make the organisation more competitive and innovative.

The main issue is for businesses to take a proactive stance regarding legislation. An example of this is to look at environmental legislation from a macro economic point of view, and how it affects job creation. If we take the Waste Management Hierarchy (explained in the previous chapter), we can say that when Governments pass regulations to enforce businesses to move upwards in the hierarchy you can create different types of jobs. Figure 3.3 represents this analogy.

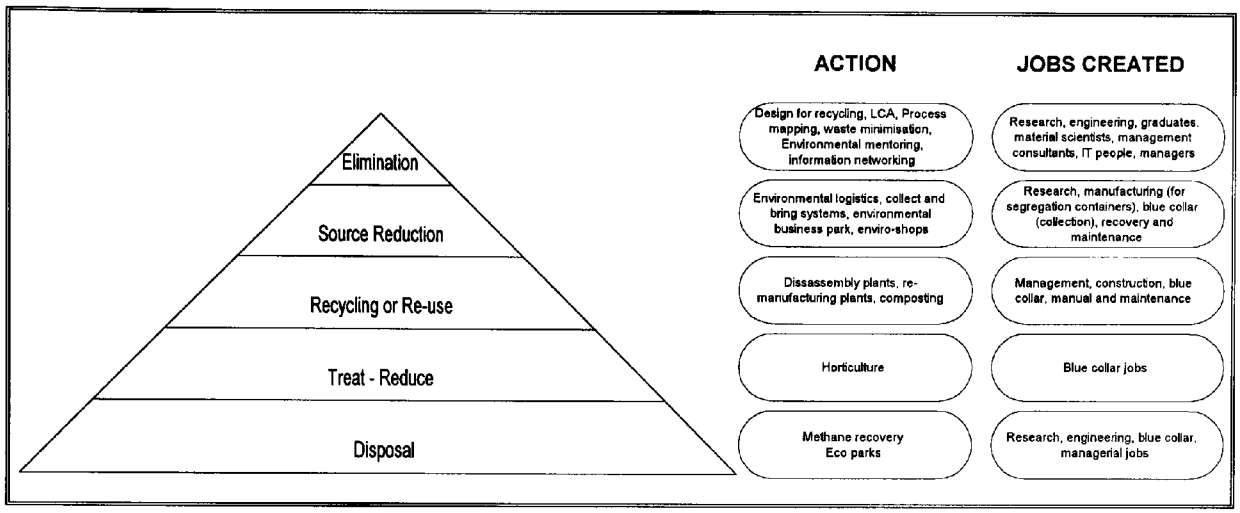


Figure 3.3 - Job Creation while Moving Upwards on The Waste Management Hierarchy

If we take the introduction of the Product Take Back Directive, this will be linked at the recycling stage, so this legislation will force companies like Sony to establish a re-manufacturing plant to recycle the TV sets and VCRs that they will have to take back from customers. This proactive attitude towards the new legislation will create management, research, construction, blue collar, manual, and maintenance jobs (Oliveira and Lloyd, 1997).

On a micro economic scale, if we take the Packaging Waste Regulations 1997, as an example we can examine the two stances companies may adopt. These regulations impose recycling and recovery obligations on businesses carrying out packaging activities. For the purposes of the legislation, packaging is defined as any item that is used for the containment, protection, handling, delivery or presentation of goods[5]. Packaging can therefore include such items as boxes, containers, tubes, bags, sacks, pallets, etc., made out of a variety of materials such as paper, board, glass, plastics, etc. The company can either have a passive stance and not do anything about it and then be prepared to pay the price, or can actually take advantage of the legislation to reduce its costs by reducing the amount of packaging used in their products.

[5] The Producer Responsibility Obligations (Packaging Waste) Regulations 1997

It has been proved by numerous case studies (Eden, 1996) that small and medium-sized businesses can develop new and more sustainable ways of working that can help to cut costs, increase profits and result in competitive advantage by being in compliance with legislation. Table 3.5 shows the potential savings that might be achievable in a company with a proactive stance towards environmental management. These figures are based on savings realised by 500 companies participating in waste minimisation projects undertaken throughout the UK.

Types of Waste	Scope for reducing financial & environmental costs
Raw materials	1 to 5%
Packaging	10 to 90%
Ancillary materials	5 to 20%
Consumables	10 to 30%
Electricity	5 to 20%
Gas and fuel oil	10 to 30%
Water	20 to 80%
Trade effluent	20 to 80%
Solid & liquid waste	10 to 50%

Source: ***Adapted from Eden, 1996***

Table 3.5 - Scope for Reducing Financial & Environmental Costs

3.3.3 - Consumers

The second external pressure mentioned was consumer demand, which reflects public opinion. In this era of organisations becoming customer-focussed, whatever the tendencies of purchasing are, companies must follow these tendencies. As stated previously, all the pressures cannot be looked at separately. In this case, NGOs are extremely important because they influence the media which feeds public opinion with *"green consumerism"* ideas.

Green consumerism can be defined as *"pressure from discerning consumers looking for environmentally friendly products and better environmental information"* (Eden, 1996). In some countries, green consumer activity has a long history. West Germany, for example, has identified environmentally less harmful products by the Blue Angel mark since 1978.

According to Eden, it is very difficult to measure the green market, *"I would suggest that perhaps 10 to 20% of adults buy some sort of green products regularly, ..., even so, because of the dynamism of the situation and the broadness of such definitions, it is unhelpful to take such estimates as absolute, especially as*

consumer behaviour varies considerably between different products and issues".

In order to illustrate the above, a UK Department of the Environment poll in 1989 noted that 64% of its sample had bought ozone friendly aerosols but only 25% had bought recycled paper and only 9% phosphate-free washing powder (ENDS Report, 1994).

This makes estimates of green consumerism very difficult, particularly because there are other factors such as price and publicity, which may influence someone to buy green, or not.

% adults sampled that fit definition	Definition	Company & year[6]
60%	Make a positive effort to buy environmentally friendly products, termed "darked greens" (41%) + buy environmentally friendly products if they see them, termed "pale greens" (21%)	Mintel 1994
49%	Actively seek green products	Mintel 1991
42%	Had chosen one product over another on the basis of environmental performance at least once	MORI 1990 (and again in 1994)
30%	Actively seek out environmentally friendly products rather than just occasionally preferring them, termed "green thinkers"	Diagnostics Market Research 1990
28%	Bought products because they were environmentally friendly on a regular basis	NOP for Department of the Environment 1993

Source: *Eden, 1996*

Table 3.6 - Estimates & Definitions of Green Consumers in the UK

3.3.4 - Non-Governmental Organisations (NGOs)

Voluntary environmental activism and the activities of non-governmental organisations (NGOs) or pressure groups also influence business environmental change. The environmental groups influence both directly, e.g. through lobbying offices, stores and corporate HQs (Eden, 1996) and indirectly through influencing public demand, the political agenda and media sources. For instance, Greenpeace had a considerable influence on European titanium dioxide manufacturers with its campaign against marine dumping of acid wastes and its blocking of the sea disposal of the Brent Spar Oil Platform is an example of the effectiveness of such a pressure (Price, 1996).

[6] Quoted from Eden, 1996

3.3.5 - Other Businesses (Investment, Insurance & other Sectorial Pressures)

As well as pressures on industry from legislation, consumers and NGOs, there is some pressure to assure financial investors and insurers that companies are *"greener"* and so more profitable and sustainable (Eden, 1996). Increasingly, company policy and action are being assessed in the share market and have an influence on company viability. Therefore, the need to improve this representation is an additional pressure on business to respond to environmental concerns. Environmental performance and reporting will influence companies' financial attractiveness and legitimatise their activities not only to consumers but also to insurers and investors.

The pressures arising from these sources come from requirements not only for better environmental performance but also for better environmental disclosure on that performance. Disclosure becomes more necessary and comprehensive and allows for a company to have the additional advantage of a good public image.

Reporting and validation of company environmental programmes may help to lower premiums by making responsible companies appear to be better risks, linking investment and insurance as sources of pressure. As well as the pressures from investors and insurers, businesses are influenced by other businesses more closely connected with their day-to-day operations. Suppliers and retailers have close links, which serve as channels for pressure. Since retailers have close contact with customers they are more responsive to market demand and encourage or even demand manufacturers to be more environmentally pro-active.

On the other hand, suppliers may be forced to adopt a more pro-active approach to environmental performance, since if a company wishes to produce an environmentally friendly product it needs environmentally friendly materials, and supplies.

3.4 - Environmental Management

Environmental management in theory involves the study of all technical and organisational activities aimed at reducing the environmental impact caused by a company's business

operations (Cramer, 1998).

The responses of organisations to the environmental challenges of the 1980s and the 1990s have, not surprisingly, been diverse, but can closely be classified (Henriques and Sadorsky, 1999, Roome, 1992) into the categories represented in Table 3.7 below.

Stages	Attitudes
Stage 1	Passive "Do nothing" attitude
Stage 2	"Fashion" environmentalism (e.g. environmental policy which is not followed)
Stage 3	Reactive (e.g. end-of pipe solutions)
Stage 4	Pro-active (e.g. on-site recycling)
Stage 5	Sustainable development

Source: Adapted from Henriques and Sadorsky, 1999

Table 3.7 - Categories of Potential Industry Response

Up to now, companies have concentrated mainly on adapting the business process to environmental requirements imposed by legislation and other external parties. Companies basically limit their endeavours to what is necessary (Stage 1 and 2 of the Table 3.7).

While it seems unlikely that all organisations will aspire and achieve sustainable development, the benefits of adopting a more integrated and systems-oriented approach to environmental management is gaining increasing recognition and credence. Cramer (1998) argues that the level of ambition of a company with respect to increasing eco-efficiency is the result of increased market opportunities, the internal structure and culture of the company, and the pressures to adopt environmental measures. This has also been manifested by the evolution of a number of management tools to assess and manage environmental performance.

3.4.2 - The Range of Environmental Management Tools

A number of management tools have been evolved to help individual companies to manage, improve and communicate their environmental performance. The first of these was Environmental Auditing, but recent years have seen increasing attention to the broader concept of the Environmental Management System (EMS) and growing use of Environmental Reporting as a means of disseminating information about environmental principles, goals and performance.

A commonly used definition of Environmental Auditing, is that of the International Chamber of Commerce (British Chamber of Commerce, 1994):

"A management tool comprising a systematic, documented, periodic and objective evaluation of how well environmental organisation, management and equipment are performing with the aim of helping to safeguard the environment by:

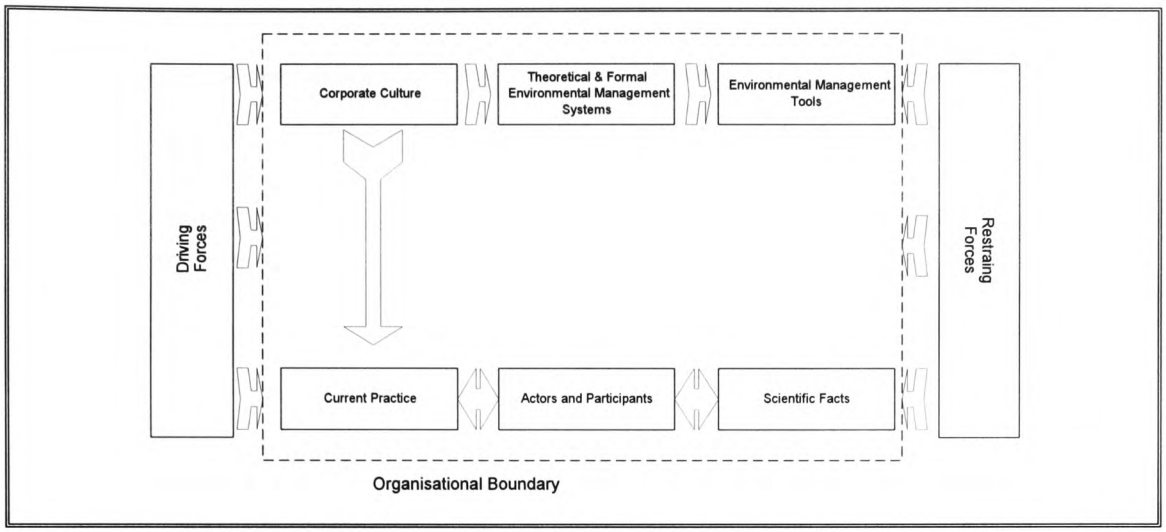
- *facilitating management control of environmental practices; and*
- *assessing compliance with company policies, which would include meeting regulatory requirements."*

Auditing alone cannot ensure that environmental practices and performance not only have met, but also will continue to meet, legislative requirements and sound corporate expectations. Moreover, audit - in contrast to assessment or inspection - presupposes that corporate systems produce the evidence which the auditor needs to form his or her judgements. For both these reasons, the EMS concept has been developed.

One definition of an EMS (quoted in Price, 1996) is:

"A systematic, documented verification process of objectively obtaining and evaluating evidence to determine whether specific environmental activities, events, conditions, management systems, or information about these matters, conform with the audit criteria, and communicating the results of this process to the client".

Elements involved in an EMSs include those shown in Figure 3.4. Environmental driving forces are factors that create or change an organisation's environmental needs. Current practice refers to issues like energy efficiency, education and training, etc.



Source: ***Adapted from Kirkland and Thompson (1999)***

Figure 3.4 - Elements of Environmental Management Systems

Figure 3.4 shows is that there are driving forces to implementing an EMS, which include legislation, customers, etc., and restraining forces such as cost, lack of expertise, as detailed in Figure 3.5. Inside the organisation factors influencing the implementation of an EMS are the corporate culture, current practice, the actors, the tools available. Corporate culture will influence the current practice at the organisation which in turn influences the actors and participants i.e. if the company has a very rigid culture it will influence the way you do things (lack of communication) that can effect the smooth implementation of the EMS.

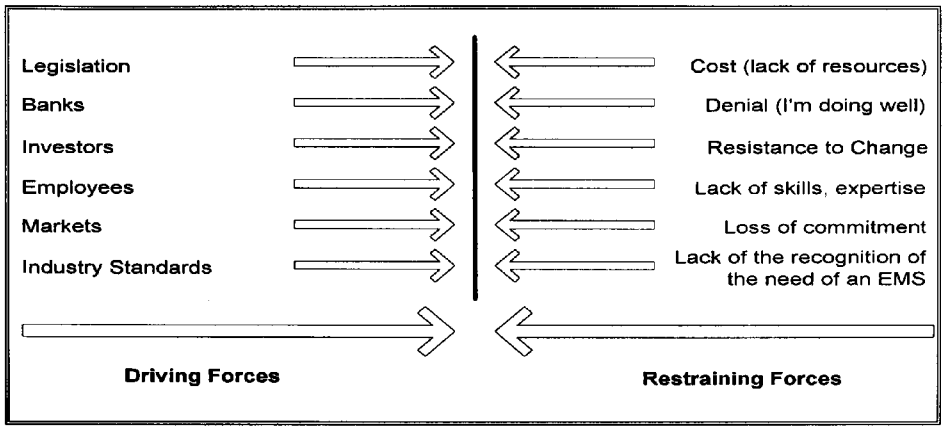


Figure 3.5 - Driving & Restraining Forces

Figure 3.5 provides an overview of the most important driving forces and barriers for the successful implementation of an EMS, but this is not exhaustive. There are without doubt more issues which may be included. The specific barriers that may affect an organisation depend on the size of the organisation, the company's culture, formal and informal management styles, individuals involved in the process and the stage of the organisation's EMS development. Many of these barriers may be related to each other. Unfamiliarity with EMS is a significant impediment to its introduction. Many organisations are completely unaware of EMS. Thirteen of thirty-two small and medium-sized enterprises surveyed by Kirkland (1997) had not heard of EMS prior to being interviewed.

A 1996 survey of Canadian small and medium-sized enterprises found that 57% of 426 respondents did not have an EMS and dealt with environmental issues on as-needed basis (KPMG, 1996). This clearly indicates that most organisations only deal with environmental issues when these become a serious threat.

Environmental issues are often given a low priority by organisations because environmental initiatives usually involve short-term costs, and benefits can only be seen in the long run. According to Kirkland (1997), problems with EMS costs are usually related to three factors. The first is that they are higher where the experience with EMS is limited. Secondly, when financing and amortising the costs of a new EMS are not done over an appropriate time

period. Thirdly, the problem is related to the benefits which are generally underestimated.

Kirkland (1997) also points out the benefits of an effective EMS. These are direct savings, such as reduction in costs of solid and hazardous waste disposal, reduced energy costs, indirect savings, through improved community and stakeholder relations (image) and easier approvals; and avoided costs, such as fines, civil damages, legal costs, clean-up costs and insurance premiums.

Corporate culture can be defined by shared values, management style or prevailing attitudes within an organisation. An EMS that radically changes the way things are done within the organisation may be perceived by decision-makers and other employees as a criticism of their work and meet with poor commitment, since it clashes with current corporate culture.

The basis of integrated environmental management is provided in Figure 3.6 below.

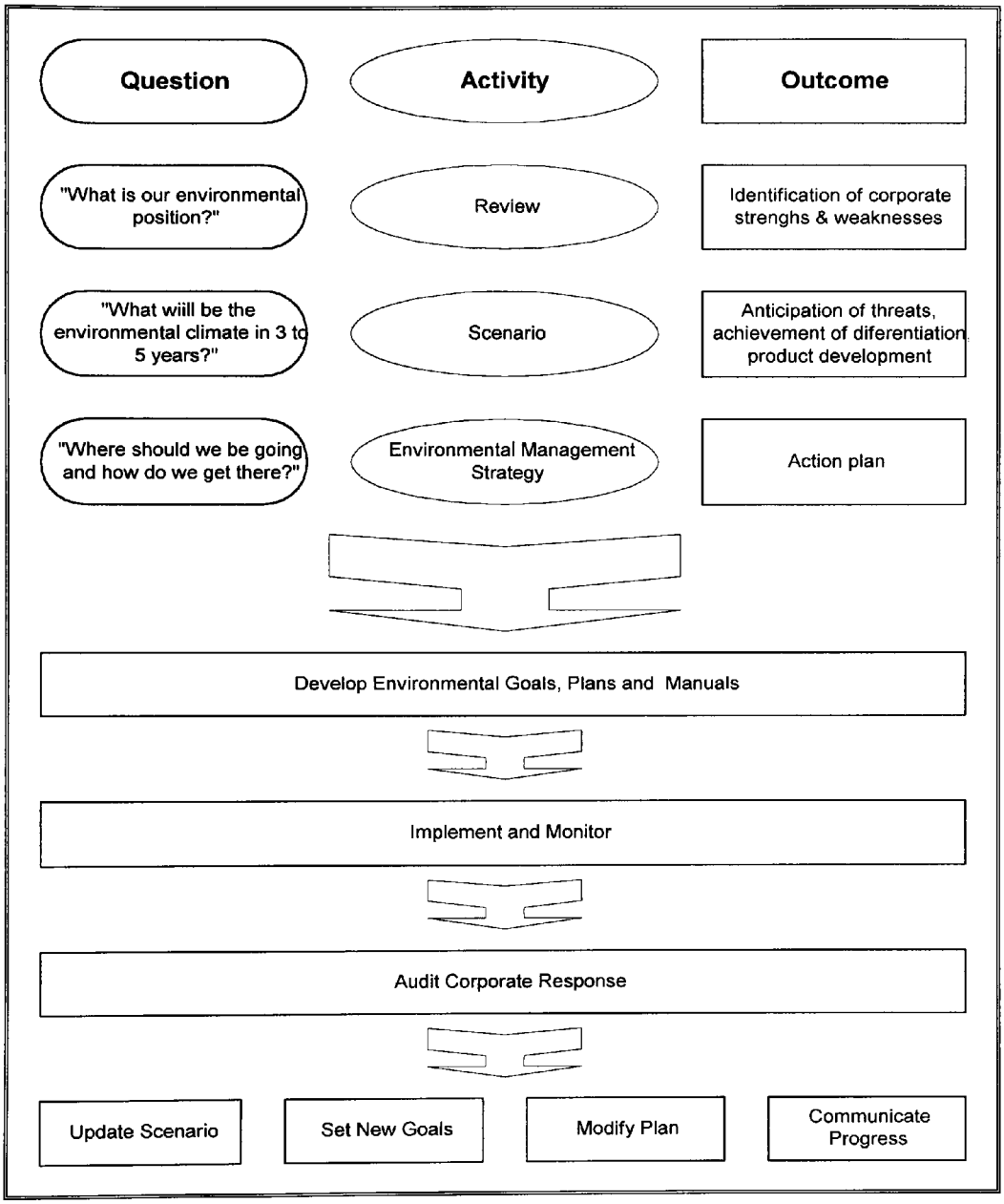


Figure 3.6 - The basis of Integrated Environmental Management

Voluntary reporting of environmental performance can:

- Demonstrate corporate commitment to environmental probity;
- Enhance confidence of, and improve interchange with, interested parties; and
- Help gain competitive advantage from environmental management and continuous

improvement.

It is however, not an activity to be entered into lightly, and there are a number of essential pre-requisites for success:

- Management commitment to environment and continuous improvement;
- An EMS in place or in development, to give the necessary information; and
- Quantified, timed goals and the reporting of progress towards them.

Production of a performance report is a major task, the fundamental steps of which are shown in Figure 3.7 below. Particular attention should be paid to planning, and careful consideration given to identifying the objectives of reporting and the target readers and their expectations, as these factors influence both the content and form the report.

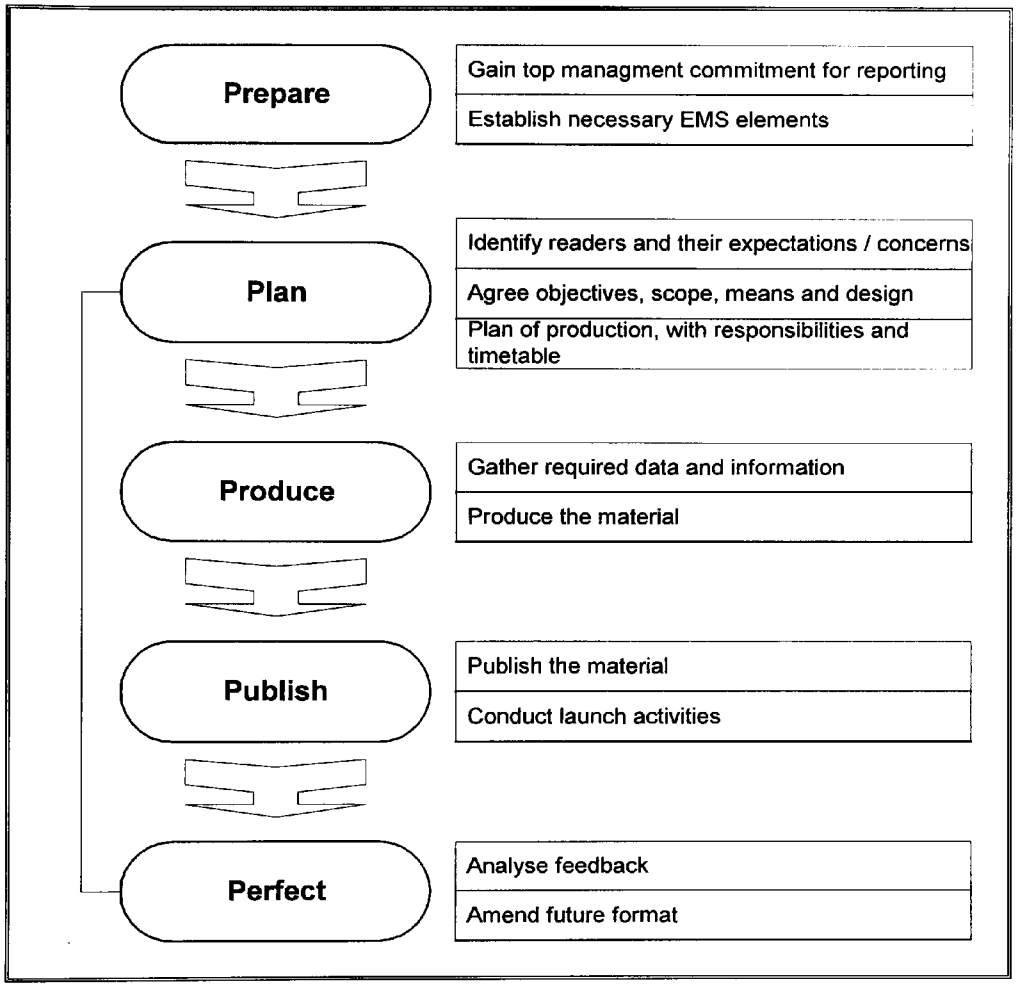


Figure 3.7 - The Steps of Voluntary Performance Reporting

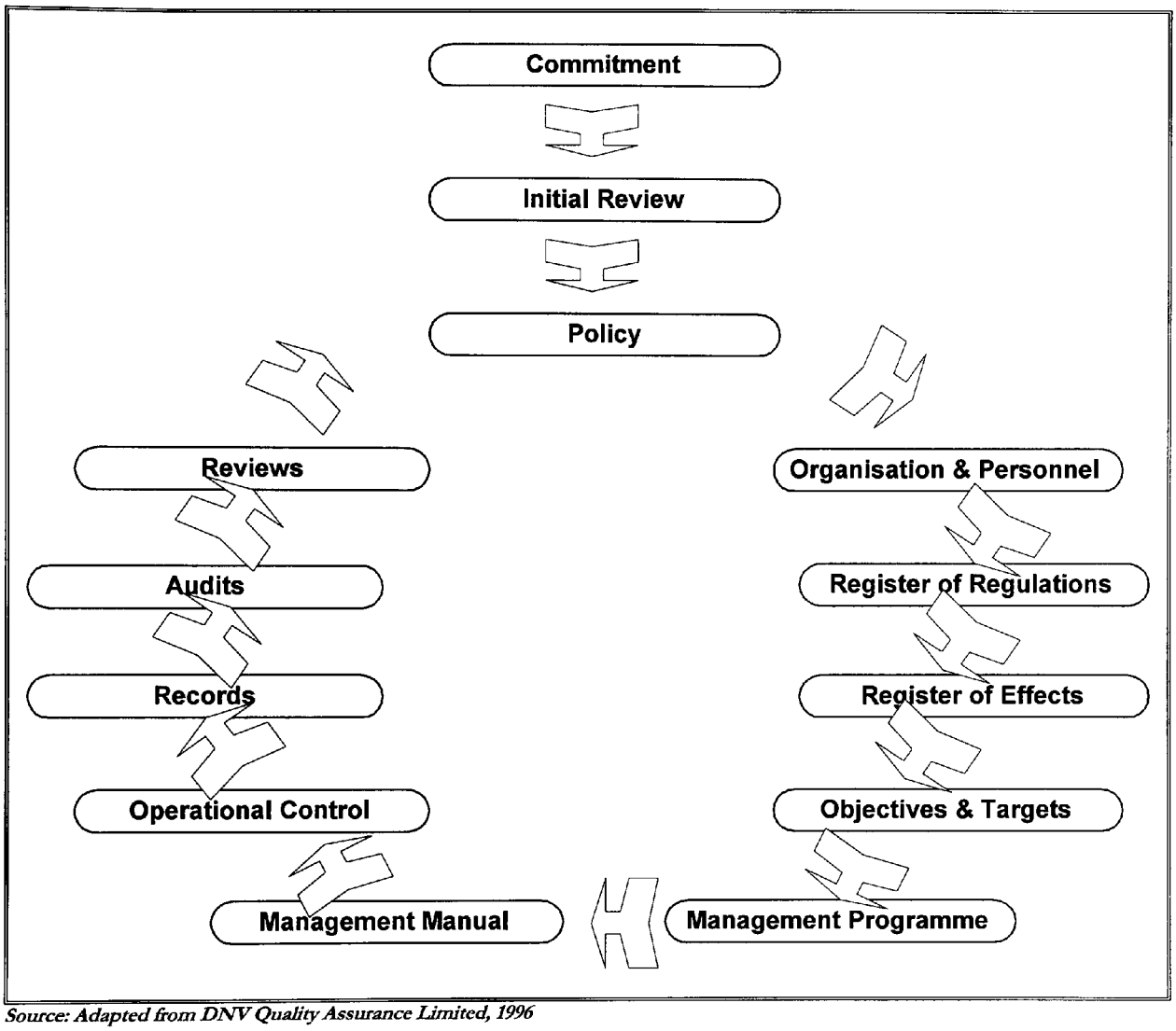
Responding to an invitation from the Confederation of British Industry (CBI) to produce a standard to facilitate environmental management, industry and the British Standards Institution (BSI) decided to develop an EMS standard compatible with the Quality Systems Standard, ISO 9000, with the following objectives (quoted in Kirkland, 1997):

- Be compatible with ISO 9000;
- Support a certification scheme;
- Be applicable to all types and sizes of organisations;

- Address operations as well as products / service; and
- Support EU and CBI initiatives, and regulatory systems.

Developed throughout 1991, the standard was published in March 1992 (DNV Quality Assurance Limited, 1996). A pilot implementation programme followed, involving some 500 organisations - including 230 pilot implementors - from most industrial, service and commercial sectors. The experience gained led to a *draft for public comment* of a proposed revision being released in July 1993.

There was little fundamental changes to BS 7750:1992, major comments related to Environmental Effects Evaluation and to amendments to ensure compatibility with the final version of the EU Eco-Management and Audit Scheme (EMAS) Regulation. A revised version of the standard was published (DNV Quality Assurance Limited, 1996) early in 1994, the EMS model underpinning it is shown in the Figure 3.8 below.



Source: Adapted from DNV Quality Assurance Limited, 1996

Figure 3.8 - The EMS Model of BS 7750

The organisation has first to establish board level commitment to environmental issues followed by an initial preparatory review. This would assess the current position of the organisation with regard to the environment. The development of an Environmental Policy is fundamental to effective environmental management.

Before embarking upon a formal policy in context of the environmental issues, the organisation must recognise that the policy must be sufficiently flexible and encompass a broad range of practical and technical issues. Any policy must be worthwhile, and not contain specifics which will not stand the test of time. It is important to recognise the policy will be

audited and monitored just as the environmental performance is monitored. The following aspects are normally considered:

- Minimisation of waste, effluents and emissions;
- Implementing effective energy management systems;
- Utilisation of life cycle analysis to determine environmental impact of raw materials, product manufacture, use and disposal;
- Supplier review; and
- Training.

In addition, the policy should:

- Be initiated, developed and actively supported by all levels of management;
- Commit the organisation to comply with all relevant regulatory requirements; and
- Secure continual improvement in environmental performance.

A lot of companies issue a broad environmental statement of intent supplemented by statements on specific issues. The specific issues (or mix) are obviously company/site issues.

In parallel with BS7750[7], EMAS has been established to improve the quality of environmental management throughout European industry, to help companies to gain a competitive advantage from these improvements, and to communicate their progress to the general public. EMAS has many similarities with BS 7750 and its requirements are:

- Initial Site Review;
- Establish an environmental management programme;

[7] BS7750 has now been superceeded by ISO 14001

- Undertake internal environmental audits;
- Externally verify audits;
- Publish an Environmental statement;
- Start verification procedure;
- Award logo;
- Ongoing audit and review.

Table 3.8 provides a comparison between BS7750 and EMAS (Klaver and Jonker, 1998) highlighting the key similarities and differences.

Key Similarities	*Key Differences*
Establish procedures and practices to minimise current and future environmental impacts of company activity	BS 7750 does not require disclosure of any further information
Integrate environmental responsibilities into every day management practice	ISO 14001 states that is good practice to make information available to the public
Require commitment to continuous improvement	EMAS requires that results are available to the public
Introduce the concept of environmental auditing	
Incorporate resource management: energy, water, waste	
Must integrate with existing quality assurance system	
Must be externally verified	
All are currently voluntary	

Source: Adapted from Klaver and Jonker, 1998

Table 3.8 - Comparison between BS 7750 / ISO 14001 and EMAS

One of the main problems of Environmental Management Systems, such as EMAS and BS 7750, is that they can represent an additional burden to an organisation if they are not integrated with other systems within the company. Environmental issues are related to other organisational issues, such as finances, profitability and overall management. If isolated, an EMS may not work at all.

3.4.3 - Environmental Management in SMEs

The London Borough of Croydon commissioned the University of Greenwich to undertake

a survey, in 1994, the main aim of which was to investigate environmental management in SMEs (Merrit, 1998). The main findings reported were that most of the managers professed a high level of environmental concern, but they had little knowledge of developments in the field of environmental management and they hadn't introduced formal practices to manage the environmental performance of their business. In general, respondents to the survey, expressed positive attitudes concerning the importance of environmental issues and the responsibilities of businesses with regard to those issues (refer to Table 3.9). However, their apparent positive attitudes were contradictory when compared with either their awareness of key business issues in environmental management or in their business practices.

Cohen and Levinthal (1990) have referred to the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends as the *"absorptive"* capacity of the organisation. This absorptive capacity tends to be greater in organisations that have financial and other resources that allow innovation to flourish.

Innovation may be particularly difficult in the case of SMEs where "absorptive capacity" is limited and where a failure to innovate may mean bankruptcy. Working with SMEs, Rosenbaum (1997) has noted that *"individual companies have neither the expertise nor understanding of EMS and there appears to be a very large fear factor".*

Irrespective of whether the business is regarded as being healthy, and progressive, SMEs tend to be very resistant to change. Environmental concerns, whether raised by business partners, government, NGOs, banks or other stakeholders may be seen as an unnecessary, unwelcome intrusion (Kirkland, 1997). Another problem with SMEs is that for them to develop an EMS they need the right skills, knowledge and expertise. Coopers & Lybrand (1995) identified that the most effective driver for SMEs to commit to an EMS was to have some significant pressure from outside stakeholders. They selected 19 companies potentially suited to have EMAS implemented (i.e. they had all previously undertaken an environmental review, they were all producers of industrial goods and they were all relatively large SMEs). Yet, despite these starting conditions, of the 19 SMEs, only one company ultimately opted to seek EMAS registration. This company was under pressure from a key customer to sign up to EMAS (Coopers & Lybrand, 1995).

The reasons why this might be so are complex. One of the explanations of this problem may be because their internal structures, processes and cultures are different from larger companies. They may also operate in a different business environment. In order for more SMEs to embrace environmental management key problem areas must be addressed.

Responses to Key Questions Relating to Attitudes	
%	**Responses**
94%	Agreed that "all businesses have a responsibility to protect the environment"
93%	Agreed or that "good energy management is an essential part of sound business management"
89%	Disagreed that "energy efficiency is not important"
92%	Agreed that "all businesses have a responsibility to minimise the waste they produce"
95%	Agreed that "waste minimisation is important for environmental reasons"
90%	Disagreed that "waste minimisation is a waste of time"
Responses to Key Questions Relating to Awareness	
%	**Responses**
46%	Unaware of BS7750
83%	Unaware of European Eco-management and Audit Scheme
84%	Unaware of CBI Environment Business Forum
95%	Unaware of Chemical Industry Association's Responsible Care Programme
72%	Unaware of Government's Energy Efficiency Office
91%	Unaware of Regional Energy Efficiency Office
89%	Unaware of Building Research Establishment's Energy Conservation Support Unit
94%	Unaware of Government's Energy Technology Support Group Unit
67%	Unaware of Croydon Energy Advice Centre
29%	Unaware of that waste management costs likely to increase significantly over the next 5 years
64%	Unaware of the fate of their waste after removal from their premises
77%	Unaware of the existence of any waste minimisation Business Clubs
Responses to Key Questions Relating to Practices	
10% have written environmental policy while 4% and 1% have separate policies for energy & waste respectively	
11% have undertaken an environmental audit while 17% and 13% have undertaken energy and waste audits respectively	
11% have designated an environmental manager audit while 10% and 7% have designated energy and waste managers respectively	
6% have introduced some kind of environmental management system while 4% and 4% have energy efficiency and waste minimisation programmes respectively	
Energy efficiency taken into account: design of new buildings (25%), refurbishment of buildings (47%), design of product (15%), design of service (19%), purchase of equipment (53%)	
Staff encouraged to turn off when not in use: lights (80%), computers (45%) heaters (74%) machinery (38%)	
Businesses recycling at least some: paper/card (22%), ferrous metal (6%), glass (3%), mixed office waste (3%), other materials (<3%).	
Businesses recycling five different materials (1%), four materials (1%), three materials (3%), two materials (8%), one material (21%), no materials (67%)	

Source: ***Merritt, (1998)***

Table 3.9 - Responses to Key Questions Relating to Attitudes, Awareness and Practices

Small businesses consume fewer resources than large corporations. This results in their managers assuming that their emissions, discharges and wastes are insignificant. On an individual basis, this may be true. However, when the environmental impacts are amalgamated as a total, this is definitely not the case. To all but a minor percentage of SMEs,

the concept of sustainable development linked to sound environmental performance is considered as either irrelevant or too a high cost (Lloyd and Oliveira, 1999).

3.5 - Summary

This Chapter reported upon the relationship between environmental issues and the pressures for change. The author starts by describing the importance of SMEs within the UK economic context, and highlights their contribution to economic growth and competitiveness.

Several pressures for environmental change are addressed with special reference to legislation which was found to act as a main driving force for SMEs to be more environmentally reactive. Another issue analysed was environmental management with a description of the range of environmental management tools available for SMEs.

Chapter 4 - The Links with Total Quality

"Quality is free. It is not a gift, but is free. What costs money are the unquality things - all the actions that involve not doing jobs right the first time." (Crosby, 1979)

4.1 - Introduction

The aim of process quality is to continuously improve towards zero defects and no waste in operations.

When you examine waste minimisation the links with total quality management become clear. In this Chapter the author proposes to examine these links in detail and highlight the tools used when developing the methodology.

4.2 - Definitions

Total Quality Management (TQM) is widely seen as the philosophy which underpins the success of many eastern competitors (Bennet and Kerr, 1996).

According to Feigenbaum (1983), total quality is defined as follows:

"Total Quality control is an effective system for integrating the quality development, quality maintenance, and quality improvement efforts of the various groups in an organisation so as to enable production and service at the most economical levels which allow full customer satisfaction"

Other definitions of quality are given in table 4.1 below:

	Definitions of Quality[8]
Juran (1974)	*"Quality is fitness for use"*
Adam & Ebert (1992)	*"Quality is doing it right first time, every time"*
Adam & Ebert (1992)	*"You pay for what you get (quality is the most expensive product or service)"*
ASQC & British Standards BS4778 (1987)	*"The totality of features and characteristics of a product or service that bears on its ability to satisfy given needs"*

Source: *Brown (1996)*

Table 4.1 - Definitions of Quality

Flood (1993) synthesises the ideas of the main protagonists in his definition: *"Quality means meeting customers' (agreed) requirements, formal, and informal, at lowest costs, first time and everytime".*

4.3 - Total Quality Management

TQM is a management philosophy that supports the process of continuous improvement within an organisation and where focus is placed upon the customer. In the socio-economic view point, TQM defines the customer as all members of society and facets of environment that interact with the activities of the company.

TQM includes such characteristics as decentralised management, which allows stakeholders their autonomy to solve problems and contribute to the decision making process. It also provides for a more meaningful methodology applied to measuring current indices of quality on all factors concerning a business.

Oakland (1993) defines TQM as *"an approach to improving the competitiveness, effectiveness and flexibility of a whole organisation".*

The core of Oakland's approach is to focus on the processes, identifying internal and external customer needs in terms of a customer-supplier chain. He states that the *"three hard management necessities"* are a quality management system, tools such as statistical process control

[8] Definitions are quoted from Brown, 1996

(SPC) and teamwork. Any or all of these three may be used *"as a spearhead to drive TQM through an organisation"*. He advocates a *"slow, planned, purposeful approach"* to implementation, which causes a gradual change so that *"business as usual"* becomes TQM. These characteristics correlate well with the recommendations made in *"Our Common Future"* (WCED, 1987) for managing industry towards sustainable development.

Stephan Robbins (quoted in Elkington, 1994) has pointed out that TQM is becoming a competitive factor that is used by companies to differentiate themselves from their competition. A company that integrates sustainable development within its TQM management processes could set itself apart from the competition, and perhaps force its competition to include sustainable development within their own operational considerations as well, thereby benefiting society as a whole. This trend should also reduce the demand from society to governments for mandates controlling business practices. John Elkington (1994), supports this trend in his article, *"Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development"*.

The very nature of TQM, and how it is implemented, requires sustainable development policy consideration. If it is not considered, then quality management for that company will likely fail, and it will probably lose its competitive advantage.

There are some common features between implementing a waste minimisation programme and the implementation of TQM, for example, continuous improvement, a structured approach, monitoring and control. This also does not conflict with environmental management which is widely quoted (Gladwin *et al*, 1995, Eden, 1996) as an important requirement for sustainable development. One of the first concerns suggested by *"Our Common Future"* (WCED, 1987) is the development of long term strategies for achieving the company objectives for sustainable development. Hodgetts (1996) suggests that this process begins by the accumulation of relevant information by posing the right questions.

What differentiates TQM from other management processes is the emphasis on continuous improvement. Total Quality Management is not a quick fix, it is about changing the way things are done forever (Kanji, 1996; Cole, 1998).

4.4 - The Management Gurus

The field of Quality Management has been strongly influenced by a number of *"Gurus"*. When analysing the work of some of these gurus, it is clear that the underlining message is reduction / elimination of waste.

The effects of quality control texts can be further illustrated with three publications in the early 1950s. They were: Quality Control (1951), later changed into Total Quality Control by Feigenbaum (1956), Quality Control Handbook edited by Juran *et al* (1988), and Introduction to Quality Control by Ishikawa (1990). All of these texts have run successive editions or reprints. Today, the impact of these texts is still being felt.

The 1960s were an exciting time for Japanese industry with the implementation of novel manufacturing management in Japan. In 1964, the persistence by the Japanese company Matsushita Electric on eliminating defects completely set Shingeo Shingo to work on developing a rational means of assuring quality to achieve the ideal of zero defect. In 1969, Shingo developed a system called Single (-digit) Minute Exchange of Dies (SMED) that was able to reduce a particular (or, single) set-up time from four hours to three minutes at Toyota (Shingo, 1992).

4.4.1 - Shingo

Shingo (1992) foresaw that rapid changeovers would change the business constitution. The Single (-digit) Minute Exchange of Dies (SMED) system (defined in Shingo, 1992) became one of the pivotal techniques of the Toyota Production System. At Toyota in 1977, Shingo developed systematic techniques for the Kanban system of non-stock production. In the same year, Shingo (1992) was encouraged by the accomplishment of *"zero defects"* at the Shizuoka plant of Matsushita Electric's Washing Machine Operations Division.

Shingo (1992), offered his Study of the Toyota Production System from Industrial Engineering Viewpoint in which, among other ideas, Kanban and Poka-yoke were discussed. Poka-yoke or mistake-proofing is a mechanism, known as automation, that automatically stops a machine in operation when an error occurs. In this way, prevention of defects is

guaranteed.

In his text on *Zero Quality Control* (ZQC), Shingo (1986) outlined the basic concepts for a ZQC system: (1) source inspections prevent defects from where errors originate; (2) 100 percent inspections rather than sampling inspections; (3) to minimise the time of corrective actions; and (4) effective poka-yoke devices fulfil control functions, without demanding humans as infallible operators (Shingo, 1986). His thinking underlining these concepts was radical. For, by thinking upstream rather than downstream, he seriously undermined sampling inspection practice, which is based on the dominant belief that statistical methods are necessary for reducing defects. By doing this, he reduced the time taken for a job, and showed a viable alternative in resolving people-machine interaction in the workplace. A full-blown application of Shingo's work at Toyota, in production operations, became known as Just-in-Time (JIT) management (Shingo, 1981; Monden, 1981a; 1981b; 1981c; 1981d; 1985). Although statistical methods allow the effective reduction of defects, they are not equipped to eliminate defects all together.

Shingo and Toyota Production System have demonstrated that zero defect is not only possible but also attainable (Monden, 1993).

In the 1970s, Shingo's work began to receive international recognition. In 1978, the sale by the Japan Management Association (JMA) of an audio-visual set of slides on SMED and pre-automation met with considerable enthusiasm in the USA. In the following year, further interest in his work was generated in the US by the JMA's sale of *"zero defects"* slides. It was the same year that the Crosby's text (1979) on *"zero defects"* and *"right first time and every time"* was published.

4.4.2 - Crosby

Crosby (1979) is best known for his *"four absolutes"* of quality, his phrase *"quality is free"*, and his 14 point plan (different from Deming's 14 points).

Crosby's *"four absolutes"* are:

1. The definition of quality is conformance to requirements

2. The system of quality is prevention

3. The performance standard is zero defect

4. The measurement of quality is the price of non-conformance

Firstly, Crosby (1979) pointed to the goal of *"zero defects"* without devising the means or identifying the meticulously due attention to the process in order to achieve the desirable outcome. This makes *"zero defects"* nothing more than a slogan. Secondly, the demand of *"right first time and every time"* appears to be stress management or technical actions alone. The effect of which could well be a separation of these actions from encouraging operators to think about how to improve what they are doing now and in the future. Thirdly, the simplistic criteria in judging one's action as either *"right"* or *"wrong"* reinforce any anxiety or fear among the workforce for doing something wrong, which may discourage workers from coming forward with constructive suggestions.

4.4.3 - Deming

Today Deming (1986) is mainly associated with quality management theories, particularly his *"14 point"* plan, the *"Deming Cycle"* and his *"deadly diseases"*.

Deming's 14 points, in summary, are:

1. Consistent message of quality throughout the organisation;

2. Commitment to continuous improvement;

3. Switch from defect detection to defect prevention;

4. Willingness to co-operate and improve with your suppliers;

5. Constantly improve (using the PDCA cycle);

6. Train in a modern way (make employees responsible for their own quality);

7. Change supervision from chasing to coaching;

8. Drive out fear of improvement (no prosecution);

9. Remove any organisational barrier that prevents quality improvement;

10. Do not have unrealistic targets;

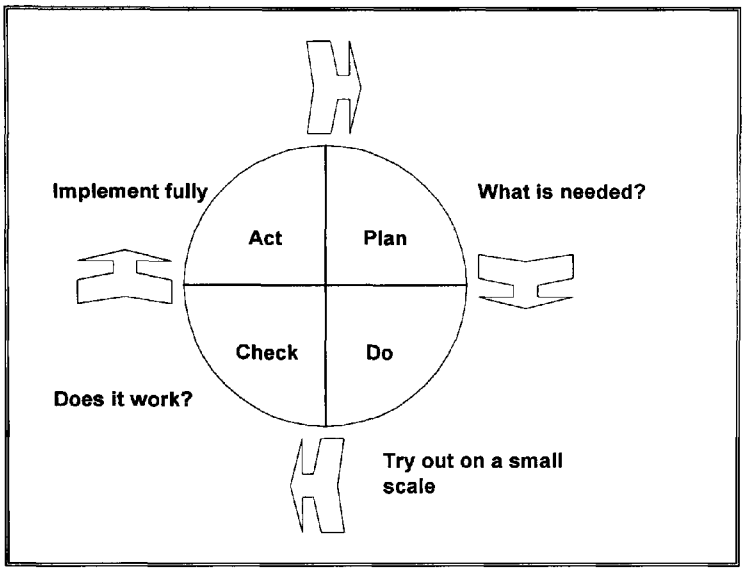
11. Work standards and numerical quotas should be eliminated;

12. Remove barriers that prevent employees having pride in their work;

13. Train and educate; and

14. Create an organisational structure that will support the previous points.

Deming maintains that the PDCA (Plan, Do, Check, Act) cycle is a universal improvement methodology. The idea is constantly to improve so as to reduce the difference in the requirements of customers and the performance of the process. The cycle is depicted in Figure 4.1.



Source: *Deming, 1986*

Figure 4.1 - The Deming Cycle

4.4.4 - Juran

Like Deming, Juran (1988) is given credit for developing Japanese quality in the 1950s. His best known concepts are his definitions of quality (mentioned above), the concepts of *"breakthrough"* and the *"internal customer"*, and the *"quality trilogy"*. Juran was also responsible for *"pareto analysis"* as applied to problem solving (explained later in the chapter) and the work on the costing of quality.

Juran (1988) believes quality is associated with product satisfaction and product dissatisfaction. Satisfaction occurs when a product has superior performance or features. Dissatisfaction occurs when there are deficiencies or defects in the product or in its service or support. Associated with this, there are two dimensions, an external one concerned with matching customer requirements, and an internal one concerned with building the product or service correctly. So quality begins with a close understanding of who the users will be and how and where the product will be used.

The notion of internal customers comes from the idea that each person along the chain, from product design to final user is both a supplier and a customer. The person will be a process as well, carrying out some transformation or activity. Taking these together, this is what Juran refers to as the *"three role model"*, that each stage is a supplier, a process, customer and user.

Juran (1988) emphasises the necessity for ongoing quality improvement. He maintains that this is only achieved through *"project by project"* improvement, or in other words by a succession of small improvement projects carried out throughout the organisation, such as in a waste minimisation programme.

Juran (1988) was the first to name the Pareto principle, which simply sets out to identify the *"vital few"* as opposed to the *"trivial many"*.

4.4.5 - Feigenbaum

Improvement projects can also be identified through cost, and Juran was responsible for suggesting that quality costs should be recorded and classified. If the costs of poor quality are recorded and known then management will be aware and it will show where the effort should be made.

Feigenbaum (1956) was the originator of *"Total Quality Control"*. He referred to the *"industrial cycle"* which is the ongoing sequence of activities necessary to bring products from concept to market. Included in this cycle are marketing, design, engineering, purchasing, manufacturing, production, inspection, packaging and shipping, installation and service. The cycle begins and ends with the customer, but in between many people and functions must play a role.

Feigenbaum (1956) is also known for his concept of the *"hidden plant"*. That is that in every factory a certain proportion of its capacity is wasted through not getting it right first time. Feigenbaum quoted a figure of up to 40% of the capacity of the plant being wasted.

4.4.6 - Ishikawa

Ishikawa (1990) extended the total quality view of Feigenbaum by suggesting that operators and employees in general, have a greater role to play in all the stages suggested by Feigenbaum. In fact, Ishikawa believed that although the total quality view was invented in the West, its potential was limited there due to over-reliance on quality professionals and insufficient attention to the contribution that everyone can make.

Ishikawa (1990) classified statistical quality control techniques into three groups of increasing complexity. The first group is the classic *"7 tools"*, and which require minimal statistical knowledge (the seven tools include the Ishikawa or fishbone diagram, which is described later in this chapter).

Ishikawa (1990) believed that quality begins with the customer. The essence is to understand customers, their requirements, what they can afford, and what their reactions are likely to be. He also believed that customer complaints are a vital quality improvement opportunity, and that they must be managed.

4.5 - Lean Management

The Japanese manufacturing system is now often considered less than one banner with a range of titles, but most widely known as lean production (Pilkington, 1998).

The lean concept was proposed by the International Motor Vehicle Program's (IMVP) study of the world auto industry, and reported in the *"Machine that Changed the World"* (Womack *et al*, 1990). Others followed this text, and they promoted the idea that Japanese car manufacturers had developed a new form of production that was more efficient that Henry Ford's mass-production system (Pilkington, 1998). As a result, lean production became the model for the 1990s manufacturing, and many managers extended their existing Japanisation (JIT and TQM) programs accordingly.

Toyota's approach to labour reduction was first publicised by Cusumano (1985), who described it as a waste reduction philosophy and compared it to the approach at Nissan. He

explained the differences by considering the relative historical performances and trajectories of each firm. Toyota's focus on waste used across a range of products including sewing machines and pre-fabricated buildings, but evolved slowly from a system first used to free capital from work in progress at a time of crisis.

Unfinished goods were mounting up as poor deliveries caused shortages of key parts in the assembly operation. By reducing the level of stocks in the production process, and assembling each product in a batch of one, Toyota was able to identify the shortages and prevent the assembly of unfinished vehicles. The just-in-time system then moved on to the removal of labour from the production system. Its development is covered in great detail by Shingo (1978, 1981, 1986, 1992), and in particular by Ohno and reported by other authors (Pilkington, 1998)

Apart from designing a system with low levels of labour costs, the heart of making the Toyota system work is the kanban - a system that links one production operation to the next, matching the production of parts closely to the demand established in the final assembly area. In essence, the Toyota system takes orders from customers (but only those which fit a predetermined plan) and then responds rapidly by assembling the car to the specification demanded.

Honda similarly aspires to manufacturing efficiency and waste reduction targets, but the driving force behind its operations strategy is to support the quality of engineering design. Honda's production systems, used for both motorcycles and cars, seek to minimise the variations in the manufacturing process in an attempt to ensure that the vehicles meet the design specifications. The manufacturing strategy is to produce vehicles in large batches, not the batch-of-one / JIT approach favoured by Toyota. Repetition is seen as the key to producing vehicles that conform to the engineering specifications. With such a strategy comes a focus on product specification simplification and stable production schedules that evolve slowly over a long period of time. This is quite unlike the rapid response of the Toyota system, but it shares some of the JIT techniques (the kanban system) to ensure the smooth running of the final assembly operation and the close links to component manufacturing areas and suppliers.

There are five steps that successful companies take in pursuing *'Lean Thinking'*[9]:

1. Define the precise value of the product - failure to specify value correctly before applying lean techniques can easily result in providing the wrong product or service.

2. Identify the entire value stream for each product or product family and eliminate waste - The organisational mechanism for defining value and identifying the value stream from concept to launch, order to delivery, and raw material to finished product is the lean enterprise.

3. Make the remaining value-creating steps flow – this means working on each design, order, and product continuously from beginning to end so that there is no waiting, downtime, or scrap within or between steps. This involves introducing new types of organisations or technologies. Lean thinkers also believe in radical improvement.

4. Design and provide what the customer wants only when the customer wants it - eliminate obsolete products.

5. Pursue perfection - a more precise definition of value always challenges the steps in the value stream to reveal waste, and getting value to flow faster always exposes waste.

The last step towards lean thinking is the pursuit of perfection. Any business must be measured by its ability to make enough profit to renew itself. Lean thinking could be the antidote to economic stagnation. As layers of waste are stripped away, more waste is always exposed. Despite the performance leaps that any company makes, it can still identify as many opportunities for improvement today as it can in four years time, and this is the key to lean thinking.

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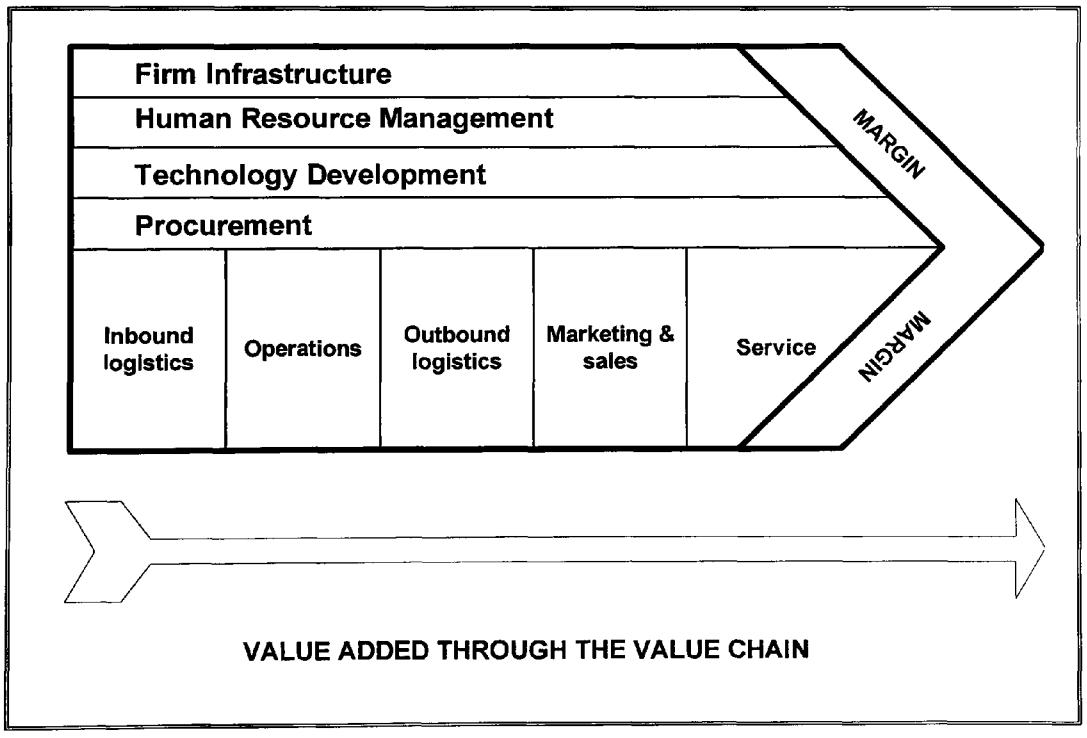
[9] This is best illustrated in the Lantech case study published in the article by Womack and Jones (1996) "Beyond Toyota: How to Root Out Waste and Pursue Perfection", Harvard Business Review

4.6 - The Value Chain

Porter's (1985) value chain model has direct relevance for manufacturing firms. He states that:

> *"Value is the amount buyers are willing to pay for what a firm provides them... creating value for buyers that exceeds the cost of doing so is the goal of any generic strategy. Value, instead of cost, must be used in analysing competitive position."*

To this end, all activities within the firm form part of the value chain. The task for the manufacturing firm is to analyse those activities, which it does best, and to focus on these. This means focusing on its core strengths and using this capability to provide added value for the firm's customers. Figure 4.2 depicts graphically the value chain.



Source: *Adapted from Porter, 1985*

Figure 4.2 - The Value Chain

Porter (1985) divides the activities within the Value Chain into primary and support activities.

Primary activities are:

1. *Inbound logistics.* These are all inputs to the product including inventory control.

2. *Operations.* All activities related to transforming inputs into final product.

3. *Outbound logistics.* Collecting, storing and distributing the product to buyers.

4. *Marketing and sales.* Providing the means for buying the product, as well as the inducement to do so (advertising, selling, distribution, pricing and promotion).

5. *Service.* Enhancing the value of a product, e.g. installation, training, repair and maintenance.

Support activities are as follows:

1. *Procurement.* Purchasing raw materials, supplies and other company assets.

2. *Technology development.* Developing know-how, procedures and technological input.

3. *Human resource management.* Selection, appraisal, training and development.

4. *Firm infrastructure.* Includes all general management activities and support systems.

Each link of the value chain shouldn't be seen as a stand-alone factor, but all the chain should be seen as a fleet of inter-linking chains (Porter, 1985). Porter viewed these inter-linking chains as separate entities, but in fact we must view manufacturing companies as part of an interactive, fluid relationships between raw materials and end customer, and also joint ventures between companies (Brown, 1996).

When we look at Porter's Value Chain (Porter, 1985), we must see that, although value is created throughout the chain, non-value-adding work (waste) is also created. This is the factor that makes companies fail since, in the nineties, companies are competing on cost reduction (Porter and Van der Linde, 1995). This can be explained in Figure 4.3 below. In order for companies to survive they have to increase the value throughout of the value chain and at the same time eliminate waste.

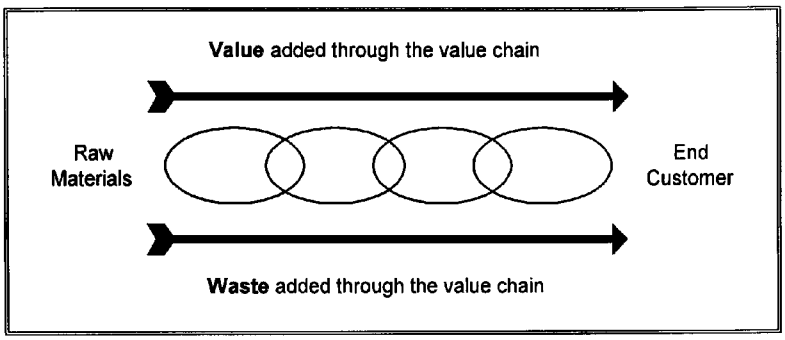


Figure 4.3 - Creation of Waste in the Value Chain

The scale of non-value-adding work is hard to grasp. Different experts quote different figures. Inefficiencies, distractions, corrections, revisits, waiting, and queuing all waste time and cause delays, lost opportunities, and huge amounts of extra cost.

Further analysis of the value chain suggests that an understanding of a firm's internal value chain provides insights that can lead to the generation of competitive advantage. An opportunity for SMEs is that environmental performance will be carried out in direct linkage with its customers, suppliers, regulators and other stakeholders. Another example of competitive advantage is given on Table 4.2 below:

Opportunities to add value	Activity	Opportunities to create value
Identify existing customers and their environmental preferences	Market Research	Anticipate developing customer priorities through innovative market research & marketing

Table 4.2 - Opportunities to add and create value in the value chain

4.7 - Quality Awards and Self Assessment

The introduction of various quality awards has provided impetus for the implementation of TQM (Aly, 1997). Several authors (Zairi, 1994; Aly, 1997; Wilson and Corry, 1997; British Quality Foundation, 1997) argue that self-assessment is essentially a tool for helping organisations in a variety of ways, including:

- Providing the opportunity to take a broader view on TQM is impacting on various business operations;
- Measuring performance of processes, and enablers and their relationship with results;
- Measuring in financial and non-financial areas;
- Measuring internally and externally, including the community and the environment;
- Encouraging objective assessment through third-party involvement;
- Providing the opportunity to benchmark and compare;
- Measuring for improvement rather than for hard control; and
- Creating the desire to do better and win awards.

According to several authors (Aly, 1997; Conti, 1997) self-assessment is also recognised for its power to improve and influence total quality implementation. The purpose of self-assessment is about learning what are the organisation's strengths and weaknesses are, providing for a perspective of the total organisation and involving everyone in its outcomes.

4.7.1 - Quality Standards

Quality standards are national levels of quality, examples include the Japan's Industrial Standard, the British Standards BS 5750 and the European ISO 9000 which is used in Europe. In the United States, a number of American standards, originally linked to military

specifications, have been used in industries. An example of this is the Baldrige Award. One of the criticisms of these quality standards is that the only thing they prove is that the company has a quality system in place rather than actually delivering a good quality product. It is important to keep in mind that it is the customers that decide the quality of the firm's products and services and not the quality system.

4.7.2 - The Deming Prize

The Japanese Union of Scientists and Engineers (JUSE), in recognition of Dr. W. Edwards Deming's contribution to the enhancement of industry quality in Japan, established the Deming Prize in 1951.

The prize recognises significant achievements of distinction that have improved performance of enterprises or divisions through the application of company-wide quality control strategies.

Winners of the Deming prize were reported (Zairi, 1994, Aly, 1997) to have the following benefits:

- Consistency in managing quality systems;
- Focus on positive quality in terms of innovation, creativity and adding value to the end customer;
- Policy management based on long-term goals rather than yearly financial returns;
- Various methods for managing quality on a daily basis, e.g. seven new tools of TQM and advanced statistical techniques; and
- Management methods catering specifically for individual firms, climate, culture and style.

4.7.3 - The Malcolm Baldrige National Quality Award

The Malcolm Baldrige National Quality Award (MBNQA) was established in 1987 to

promote the practices of quality management within US-based companies.

In the US, the MBNQA is given to firms who can demonstrate quality achievements. This award is divided in 7 categories: Leadership (worth 90 points), Information and Analysis (worth 80 points), Strategic Quality Planning (worth 60 points), Human Resource Development and Management (worth 150 points), Management of Process Quality (worth 140 points), Quality and Operational Results (worth 180 points), Customer Focus and Satisfaction (worth 300 points).

Benefits reported from winners of the MBNQA (Wisner & Eakins, 1994, Aly, 1997) in a study which compared their quality progress against business performance concluded that all 19 winners boast significant achievements in the areas of customer service, production costs, product reliability, failure rates and cycle time.

4.7.4 - European Foundation Quality Model

Regardless of sector, size, structure or maturity, to be successful, organisations need to establish an appropriate management system. The EFQM Excellence Model is a practical tool to help organisations do this by measuring where they are on the path to excellence; helping them understand the gaps; and then stimulating solutions.

4.7.4.1 - The Fundamental Concepts of Excellence

The EFQM Model is a non-prescriptive framework that recognises there are many approaches to achieving sustainable excellence. Within this non-prescriptive approach there are some fundamental concepts that underpin the EFQM Model. These are expressed below. There is no significance intended in the order of the concepts. The list is not meant to be exhaustive and they will change as excellent organisations develop and improve.

- **Results Orientation**

  Excellence is dependent upon balancing and satisfying the needs of all relevant stakeholders (this includes the people employed, customers, suppliers and society in general as well as those with financial interests in the organisation).

- **Customer Focus**

The customer is the final arbiter of product and service quality and customer loyalty, retention and market share gain is best optimised through a clear focus on the needs of current and potential customers.

- **Leadership and Constancy of Purpose**

The behaviour of on organisation's leaders creates a clarity and unity of purpose within the organisation and an environment in which the organisation and its people can excel.

- **Management by Processes and Facts**

Organisations perform more effectively when all inter-related activities are understood and systematically managed and decisions concerning current operations and planned improvements are made using reliable information that includes stakeholder perceptions.

- **People Development and Involvement**

The full potential of an organisation's people is best released through shared values and a culture of trust and empowerment, which encourages the involvement of everyone.

- **Continuous Learning, Innovation and Improvement**

Organisational performance is maximised when it is based on the management and sharing of knowledge within a culture of continuous learning, innovation and improvement.

- **Partnership Development**

An organisation works more effectively when it has mutually beneficial relationships, built on trust, sharing of knowledge and integration, with its partners.

- **Public Responsibility**

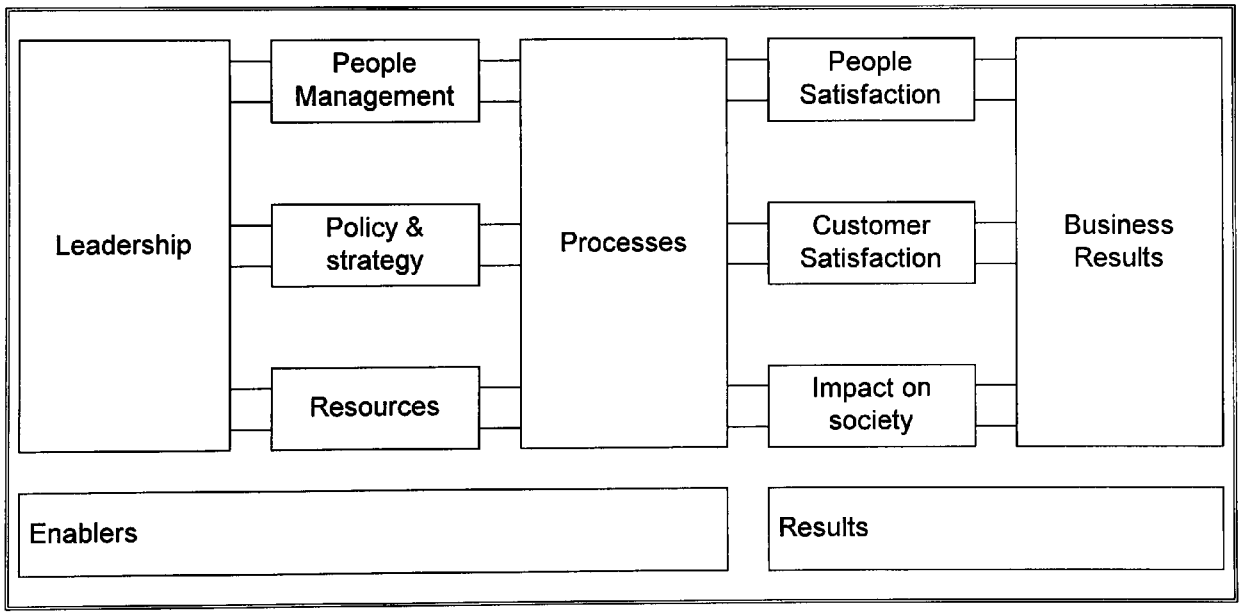
Adopting an ethical approach and exceeding the expectations and regulations of the

community at large best serve the long-term interest of the organisation and its people.

4.7.4.2 - Overview of the EFQM Excellence Model

The EFQM Excellence Model depicted in Figure 4.4 below is based on nine criteria. Five of these are *"Enablers"* and four are *"Results"*. The *"Enabler"* criteria cover what an organisation does. The *"Results"* criteria cover what an organisation achieves. *"Results"* are caused by *"Enablers"*.

The Model, which recognises there are many approaches towards sustainable excellence in all aspects of performance, is based on the premise that: *Excellent results with respect to Performance, Customers, People and Society are achieved through Partnerships and Resources, and Processes.* (British Quality Foundation, 1997)



Source: *British Quality Foundation, 1997*

Figure 4.4 - The European Foundation Quality Model

The Model's 9 boxes, shown in Figure 4.4, represent the criteria against which to assess an organisation's progress towards excellence. Each of the nine criteria has a definition, which explains the high level meaning of that criterion. (Please refer to Appendix I)

To develop the high level meaning further, each criterion is supported by a number of sub-criteria. Sub-criteria pose a number of questions that should be considered in the course of an assessment.

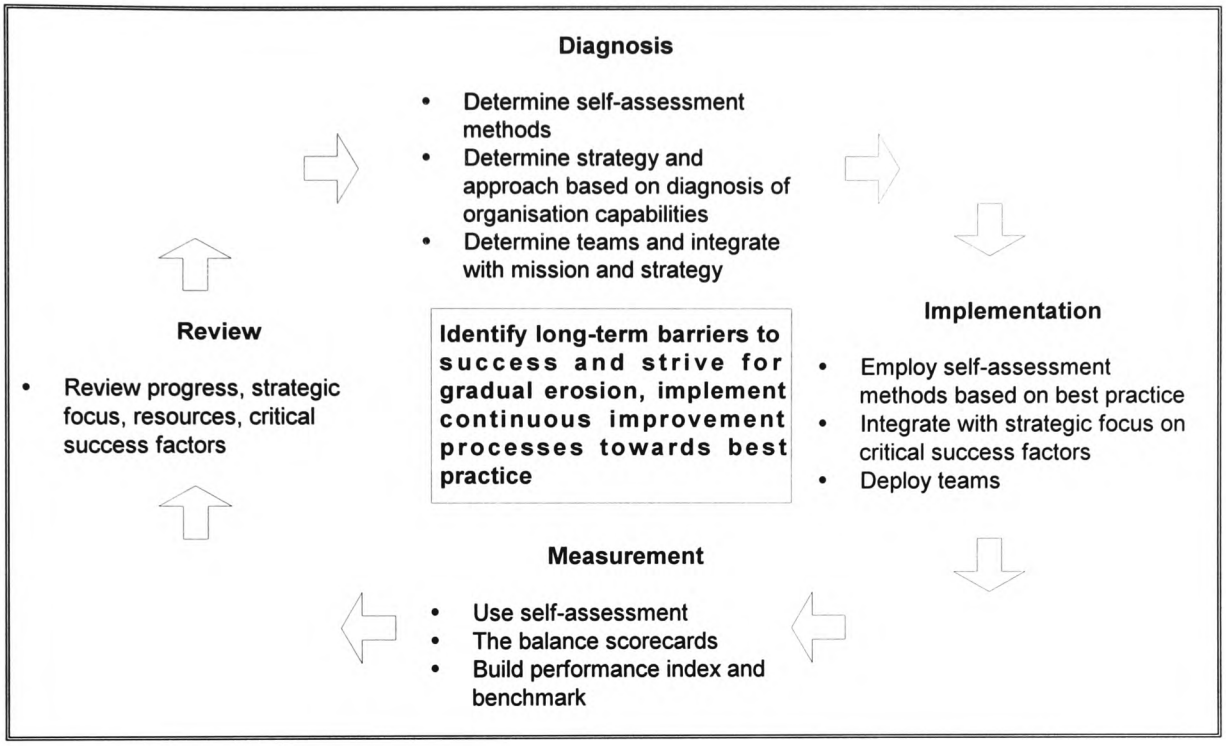
Finally below each sub-criterion are lists of possible areas to address. The areas to address are not mandatory nor are they exhaustive lists but are intended to further exemplify the meaning of the sub-criterion. To examine these lists please refer to the appendix.

The attraction of the EFQM model is its applicability to a wide number of situations, organisations and its relatively easy of use. The model itself can be considered, as a business *"system"* (Black and Crumley, 1997) comprised of inputs (i.e. shareholders expectations, leadership and people), processes (i.e. people management, strategy formulations and process management) and outputs (i.e. financial results, customer satisfaction, products and service performance).

The influence of the model on an organisation's culture, processes and systems will vary according to the way it is used, nevertheless if an organisation starts to assess itself, by whatever extent, it will inevitably generate a broad range of improvement issues and action.

Faced with a list of hundreds of improvement issues, there is a temptation to do one of five things: do anything, do nothing, do everything, do the first things on the list first, do the easiest things first. Unfortunately, none of these will necessary generate sustainable improvements. That is why it is so important to link this analysis with a programme such as the waste minimisation programme.

A new model for implementing TQM using self-assessment processes is provided by Longbottom (1997) and is depicted in the Figure 4.5 below.



Source: Adapted from Longbottom, (1997)

Figure 4.5 - A new Model for Implementing TQM Using Self-assessment Processes

The model depicted in the Figure 4.5 above can be compared to the Deming's Plan-Do-Check-Act cycle (i.e. Plan – diagnosis, Do – implementation, Check – measurement, Act – review) in order to create a culture of continuous improvement. This model can also be compared to the waste minimisation methodologies and provides a good basis for integrating the two concepts. This idea will be pursued further on the course of this thesis.

4.8 - Tools and Techniques

The discipline of quality is what drives continuous improvement. This has to be continuously measured so that costs of quality diminish and customer satisfaction increases. In order to measure current and future progress, a number of tools are typically used including Pareto

charts, cause and effect diagrams, control charts, worksheets, etc.

Tools and techniques are practical methods, skills or means that are applied to particular tasks. They are used to facilitate positive change or improvements. A tool may be described as a device which has a clear role. It is often narrow in its focus and is usually used on its own (TQM International, 1995).

Examples of tools are:

- Cause and Effects Diagrams
- Pareto Analysis
- Relationship Diagrams
- Control Charts
- Histograms
- Flowcharts

A technique has a wider application than a tool. Techniques usually require more skill and training to use them effectively. They may be viewed as a collection of tools. (TQM International, 1995)

Examples of techniques are:

- Statistical Process Control
- Benchmarking
- Quality Function Deployment
- Failure Mode and Effects Analysis
- Design of Experiments

The following is a snapshot of the quality tools used during the development and testing of the methodology (Chapter 5).

4.8.1 - The Process View

Organisations such as IBM (Harrington, 1991; Walsh, 1996), Unisys, Ford, British Telecom, (Jones, 1994; Walsh, 1996) have adopted a process view of how they conduct business. A process view requires describing the organisation in terms of business processes, assigning ownership of these processes and undertaking a strategic improvement plan based on key processes.

It requires separating the organisation's processes into those which address the needs of customers (e.g. ordering, dispatch), and those which address the needs of the organisation (e.g. accounting, finance).

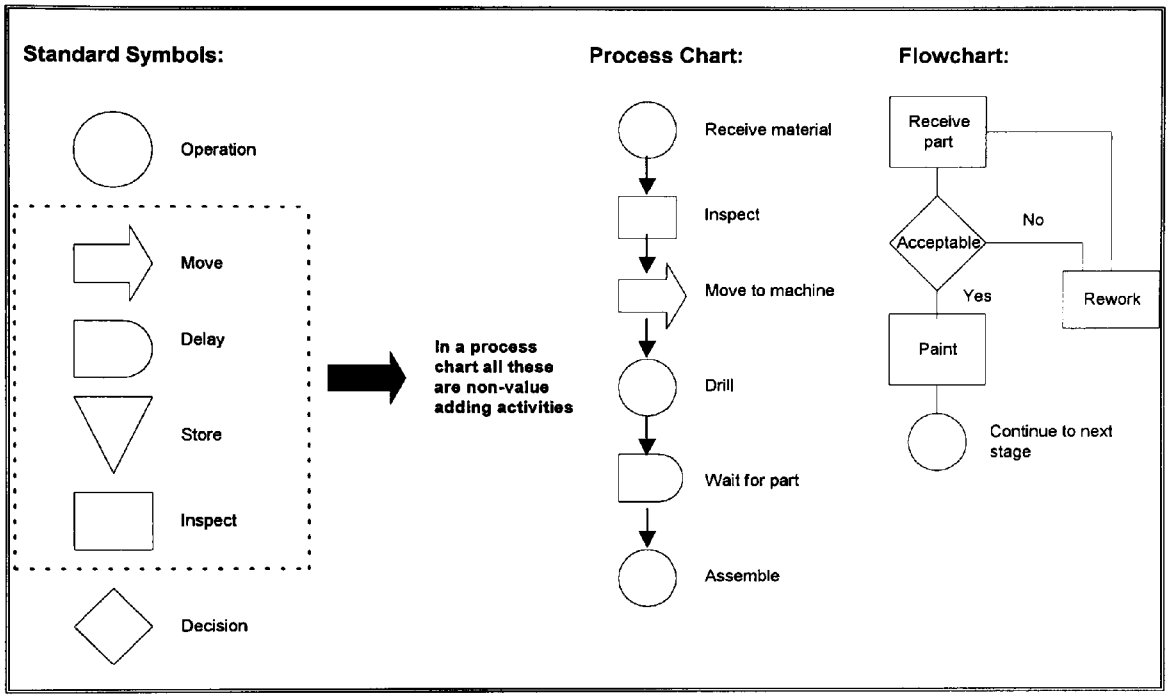
"Large" key processes are broken up into *"smaller"* sub-processes and improvement initiatives proceed on a process-by-process basis. An example of a process view can be the value chain described earlier in this Chapter.

The process view has major implications for the establishment of performance measurement systems of organisations. This tool implies that key business processes should be identified before performance indicators are developed and the indicators so developed should be aligned with what is expected from these processes. Thus, the tool suggests that performance measurement should be undertaken to improve business processes (Walsh, 1996).

4.8.2 - The Process Chart

The process chart lists every step that is involved in the manufacture of a product or the delivery of a service. It has long been used by work study officers, who usually use special symbols to indicate *"operation"*, *"delay"*, *"move"*, *"store"*, and *"inspect"* (see Figure 4.6). The process chart helps identify wasteful actions, and documents the process completely. Good communication is an important reason to do this. The systematic record helps reveal the possible sources of quality and productivity problems.

Some process charts can be very long and complicated. It is possible to break them up into sections of responsibility.



Source: *Bicheno, J. 1991*

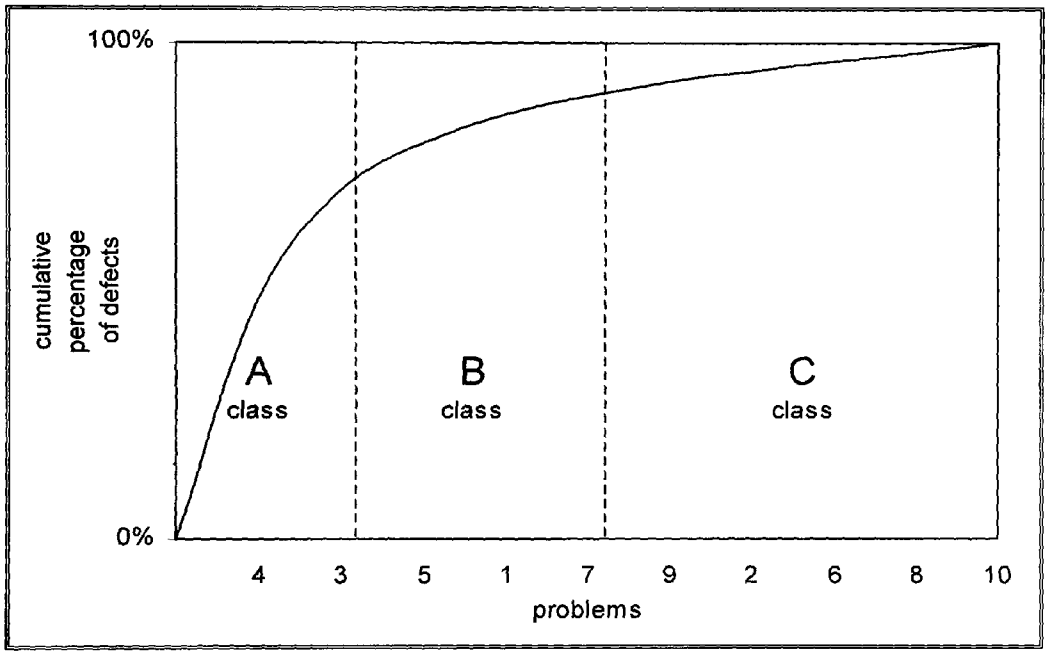
Figure 4.6 - The Process Chart and Flowchart

4.8.3 - Pareto Diagrams

A Pareto chart (Bicheno, 1991) is a graphical representation that displays data in order of priority. Pareto analysis gives recognition to the fact that, invariably, a small number of problem types account for a large percentage of the total number of problems that occur. The name *"80:20"* is representative of this.

The Pareto analysis (80:20) has many applications, an important one is analysing quality defects. Class A items will be those where 80 per cent number of occurring defects will be centre round the same 20 per cent group causes. Pareto Analysis is used to focus problem-solving activities, so that areas creating most of the issues and difficulties are addressed first. This is shown in Figure 4.7. The importance of this tool is that, unless all items are identified

and dealt with, particularly the Class A causes, competitive factors such as cost and delivery may be threatened. Pareto charts may also be used in quality circles, where groups can identify major causes themselves and then take responsibility for changing processes in order to make improvements.

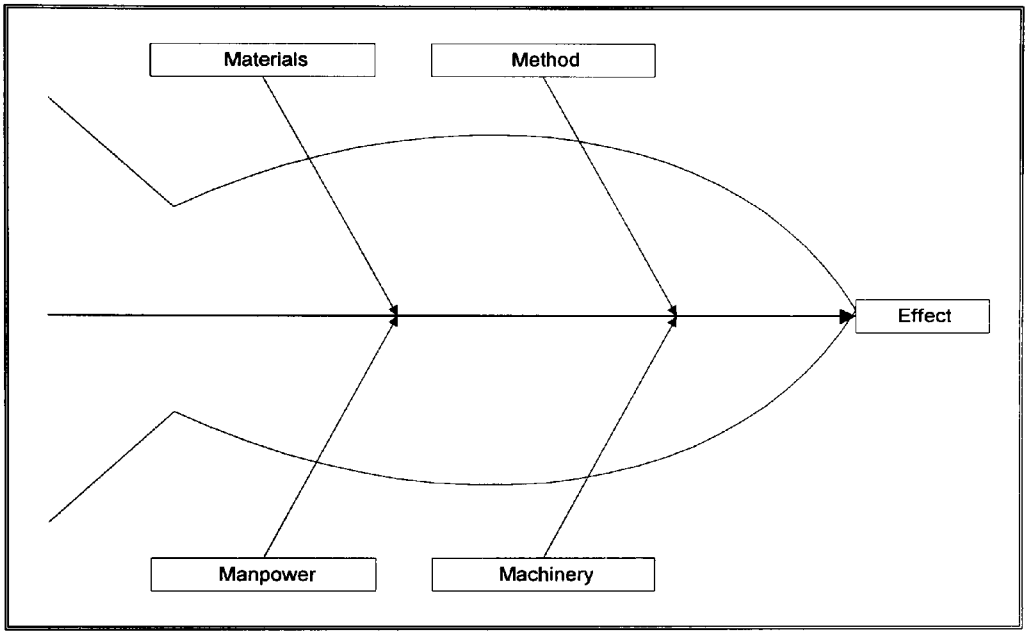


Source: *Bicheno, 1991*

Figure 4.7 - Pareto Diagram

4.8.4 - Ishikawa Diagrams

The Ishikawa diagram, also known as the *"cause and effect"* diagram or the *"fishbone"* diagram, is used to brainstorm out possible contributing causes of a particular problem. In this respect it follows directly from the Pareto diagram, with the most pressing problem becoming the spine of the *"fish"*. An example is shown in Fig. 4.8. As can been seen, contributing causes are written in on the diagram, arranged in a hierarchy. Hence the name *"cause and effect"*. Toyota divides problem awareness into four basic categories (i.e. the four initial bones): manpower, machine, methods and materials, and use this as a basis for Ishikawa diagrams (Bicheno, 1991).



Source: *Bicheno, 1991*

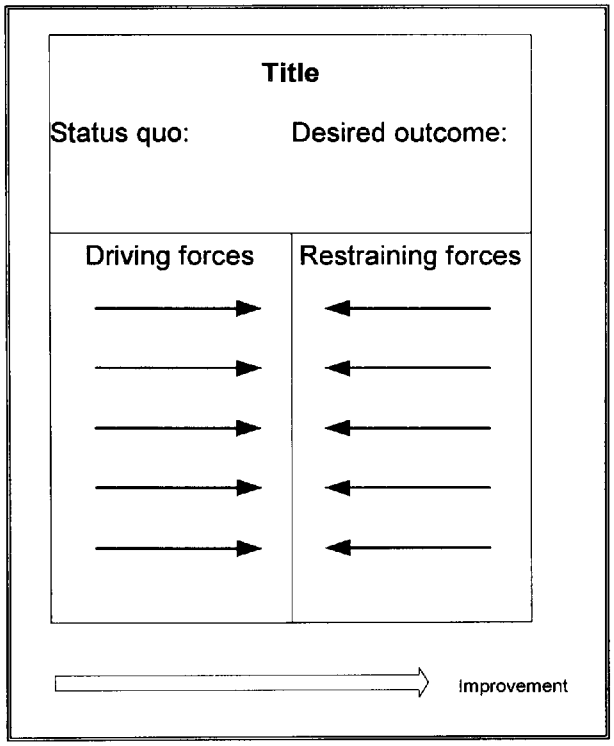
Figure 4.8 - Ishikawa Diagram

4.8.5 - Brainstorming

Brainstorming is a method of free expression and is employed when the solution to problems cannot be deduced logically and/or when creative new ideas are required. It can also be used to promote employee participation and ownership of the solution.

4.8.6 - Force Field Analysis

This tool is based on the concept that any problem is a result of forces acting on it (Bicheno, 1991). The negative or restricting forces keeps the problem at its current level. The positive or driving forces keep the problem at its current level. The positive or driving forces pushes the situation toward improvement. The former are causes of the problem, the latter are potential solutions. The tool is often used with Cause and Effect Analysis to identify potential solutions to the causes of the effects.



Source: *Bicheno, 1991*

Figure 4.9 - Force Field Analysis

4.9 - Summary

This Chapter described the links between waste minimisation and total quality management. The author begins by exploring the meaning of total quality and describing the management gurus, and throughout the text establishing where total quality overlaps with waste minimisation principles, such as the *"zero defects"* principle of Crosby. The author also provides an overview of total quality tools and techniques that are used in the different waste minimisation methodologies described in Chapter 5.

Part of this Chapter is dedicated to quality awards and self-assessment, particularly the EFQM model since this tool was used by the author when applying a waste minimisation methodology in pilot companies (refer to Chapter 5).

Chapter 5 - Waste Minimisation in Practice

5.1 - Introduction

"Never before has it been so apparent that by changing our working practices, rethinking our attitudes to waste reduction and making a more determined effort at recycling, we can not only make a difference to the environment, but save a significant amount of money for both ourselves and our clients" (Tarmac Building)[10]

The author has been describing, during the course of this thesis, the different issues that face SMEs in terms of environmental management and waste minimisation. A literature survey was undertaken of several areas, namely waste minimisation in context, environmental issues and the pressures for change, and the links with total quality. By analysing these areas the author found that there were several issues that required further scrutinising as part of this research:

- ***The SME sector*** – SMEs were found to be a major source of innovation and competition which contributes to create a dynamic, and healthy market economy. Currently any action taken by SMEs regarding environmental legislation is often a negative response rather than positively seeking new opportunities from environmental management. SMEs appear passive or at best reactive on environmental issues, displaying none of the innovative characteristics associated with the sector.

- ***Sustainable Development*** – Research undertaken by other authors has illustrated that there is a need for radical change in attitudes and practices of SMEs if sustainable development is to be achieved. It has also been shown that this is unlikely to occur through the application of a standard based on management systems on the large business model. These EMS serve as a comparative reference system for use in achieving targets set by management. They cannot act as a holistic solution to the problem of environmental degradation.

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[10] One of the companies participant on the Sustainable Business in Action (SABINA) project (Welsh Office, 1997)

In their paper discussing the paradigms for sustainable development, Gladwin *et al* (1995) quote the World Bank *"the achievement of sustained and equitable development remains the greatest challenge facing the human race"*. They add to this and say that *"transforming management theory and practice so that they positively contribute to sustainable development is the greatest challenge facing the Academy of Management"*.

The findings of this PhD thesis are a modest contribute to this challenge.

In order to analyse how waste minimisation is being embraced by the SME sector, the author presents and analyses in this Chapter different waste minimisation programmes – The Environmental Enterprise Project, the Environmental Mentoring Project, Sustainable Business in Action (SABINA), Project Catalyst and, the Aire and Calder Project. Two of the five programmes had the direct involvement of the author (as project researcher), namely the Environmental Enterprise, and the Environmental Mentoring Projects.

5.2 - The Environmental Enterprise Project

The Environmental Enterprise Project was supported by an ERDF grant under the name *"Generating Wealth and Jobs in South Wales by Implementing Effective Waste Management in SMEs"*. Within this project, a steering group was formed with the University of Glamorgan and William Battle Associates and eight SMEs to implement effective Waste Minimisation procedures.

The project consisted of three stages:

Stage 1 - Scoping Study of Waste Management Practices with Companies Throughout South Wales. This study researched the current activities of SMEs and the opportunities available for SMEs in the areas of waste management: waste reduction, clean technologies, waste re-use and recycling. The resulting analysis from the stage 1 leads to stages 2 and 3.

Stage 2 - Waste Minimisation Advice to SMEs. Following on from the scoping study, 8 students from the University, (final year BSc Energy and Environmental Technology/MSc schemes on Quality, Energy and Environmental Management were selected for a 6 week placements

at a company. Students were given a methodology to follow in order to identify waste and cost savings (drawn upon the methodology described in the GG38 Guide). This methodology was called the *"structured process mapping approach"*.

Stage 3 - Dissemination of Results. Case Studies were published through the Environmental Technology Best Practice Programme, and presentations were made at conferences supported by the Welsh Office.

The Environmental Enterprise Project objectives were:

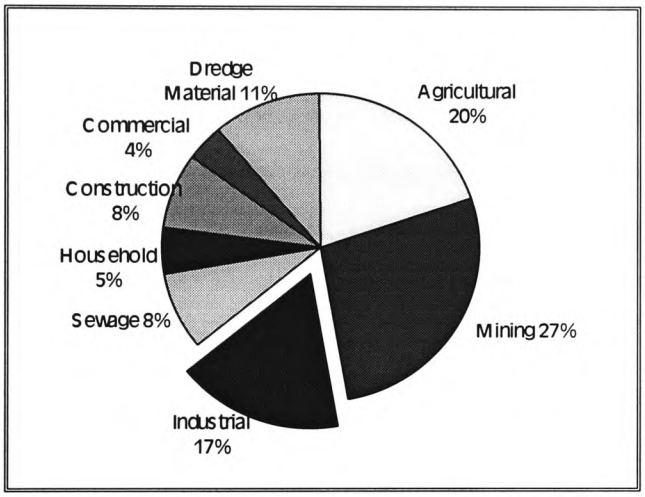
- to assist in the implementation of clean technologies and innovative methods of waste management in SMEs;
- to raise awareness amongst SMEs in South Wales of the technologies available for more effective management, through the dissemination of best practice and the results evaluation of the study;
- to assist SMEs in improving processes of production to include environmentally-sensitive waste management techniques;
- to encourage job creation in the region, in the field of waste minimisation and environmental technology by demonstrating cost savings;
- to support the implementation of a policy to ensure sustainable development for the region.

5.2.1 - The Scoping Study

The scoping study was undertaken by the author and consisted of a survey directed at 200 manufacturing SMEs. As previously mentioned throughout this thesis, waste, being an unloved by-product of inefficient processes, is a subject most people would choose to ignore, and that is why it is so difficult gathering data relating to waste arising and disposal. The survey intended to research the current activities of SMEs regarding environmental performance as well as identifying opportunities for improvement. A copy of this survey can

be found in Appendix II.

The Department of the Environment, by categorising waste according to its sources, estimates that around 400 million tonnes of waste per year are produced in the UK. Mining, agricultural and industrial sectors are the three main "producers" accounting for over half of the waste arisings (Figure 5.1).



Source: DoE, 1995

Figure 5.1 - Waste Arisings in the UK (Annual tonnage: 400m)

Industry's attitude to waste has been a reflection of society's perspective. Managing waste has traditionally been regarded as largely irrelevant to business performance by a large number of companies. This situation is best illustrated by some of the findings of a MORI survey (Biffa Waste Services, 1994) of a representative sample of one hundred companies on their attitudes towards waste.

- Nine out of ten managers say minimising the cost of waste disposal is important, but eight out of ten do not consider their competitors' waste practices important.

- While almost all (96%) felt that compliance with the Environmental Protection Act 1990 was important, three in five were not aware of the penalties of breaking the law.

- About one in ten did not know anything about the Environmental Protection Act or

its implications.

- Over half say they are not concerned about their shareholders' view on their company's waste practice, but a similar proportion say that their customers' views are important.

This survey also reveals that the waste policy of a company, if one exists, is seldom the direct responsibility of a board director.

The survey undertaken by the author had a response rate of 22%. Most of the companies examined had between 50 and 250 employees (falling into the SME category as defined in Chapter 3). The initial response rate was improved through follow-up phonecalls. All respondents had formalised Quality Management Systems, but there was little evidence to suggest that they monitored waste or the cost of waste. The conflicting information confirmed that even *"quality-oriented"* companies had no formalised method of identifying waste streams and indeed how companies perceived waste varied with most identifying it, but not measuring or recording it, as what was thrown into the rubbish skip. All percentages given are rounded to the nearest whole number.

Figure 5.2 represents the results from section two of the questionnaire. Although the answers show that 70% of the companies have an environmental policy, 70% carry out environmental assessments and 60% undertake environmental audits, through follow-up phonecall interview it became evident that no measure or control was dedicated to the production of waste.

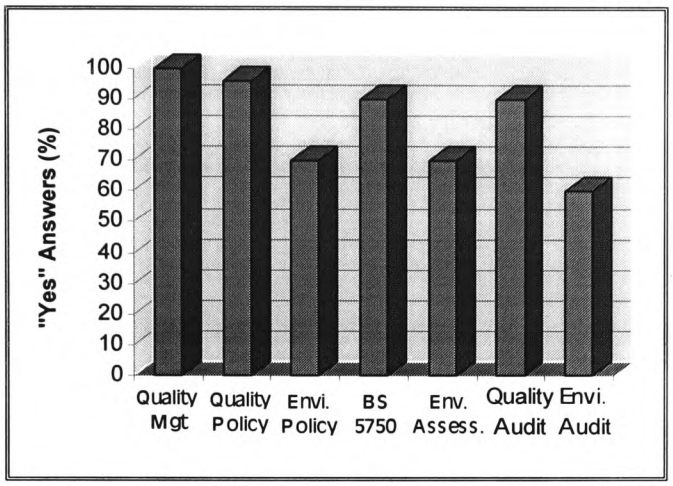


Figure 5.2 - Quality and the Environment

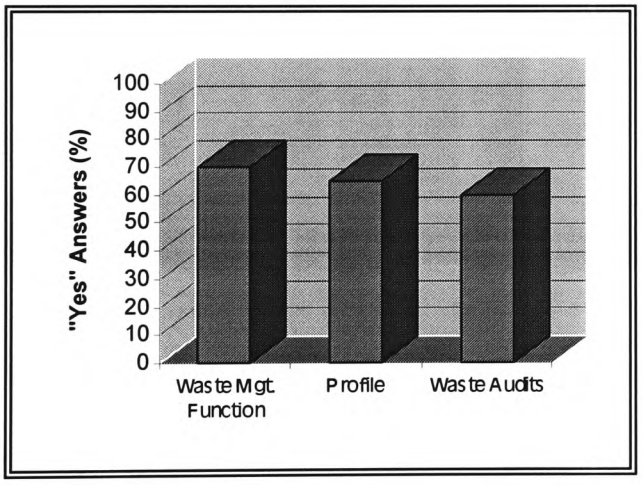


Figure 5.3 - Waste Management

In section 3 of the questionnaire, there was an attempt to identify if the company had knowledge of the amount of waste generated, and the importance of waste minimisation. Figure 5.3 shows that, although companies answered that they had a waste management function (70%), and that they considered waste management important (65%) and they undertook waste audits (60%), none of the companies was able to answer question 3 from

section 3 - quantify the volume of waste generated.

Figure 5.4 shows that the most common method of disposal came at the bottom of the waste hierarchy - landfill.

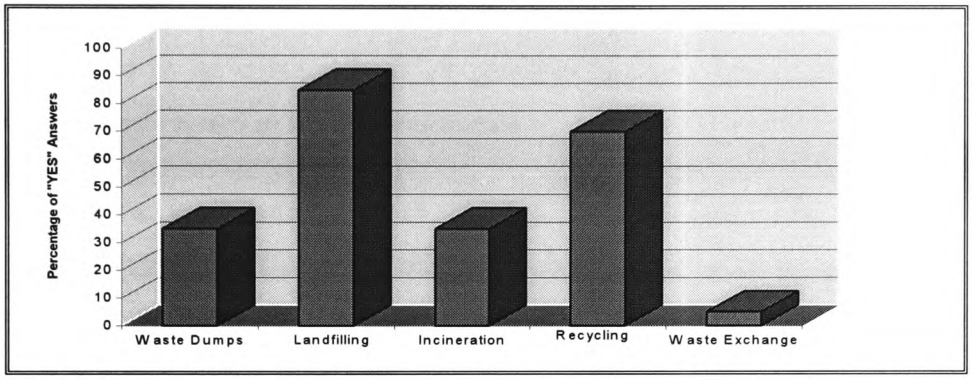


Figure 5.4 - Disposal methods

The findings of the MORI survey (Biffa Waste Services, 1994) in 1993 of a 100 companies sample indicated that, although people were concerned about waste management, they didn't know exactly what it was. This study, undertaken by the author, also has shown that managers are concerned about waste, and consider it important (70% of companies have an environmental policy) but it also demonstrated the absence of companies monitoring waste (no company was able to quantify the volume of waste generated a month), or perhaps more importantly, the cost of waste.

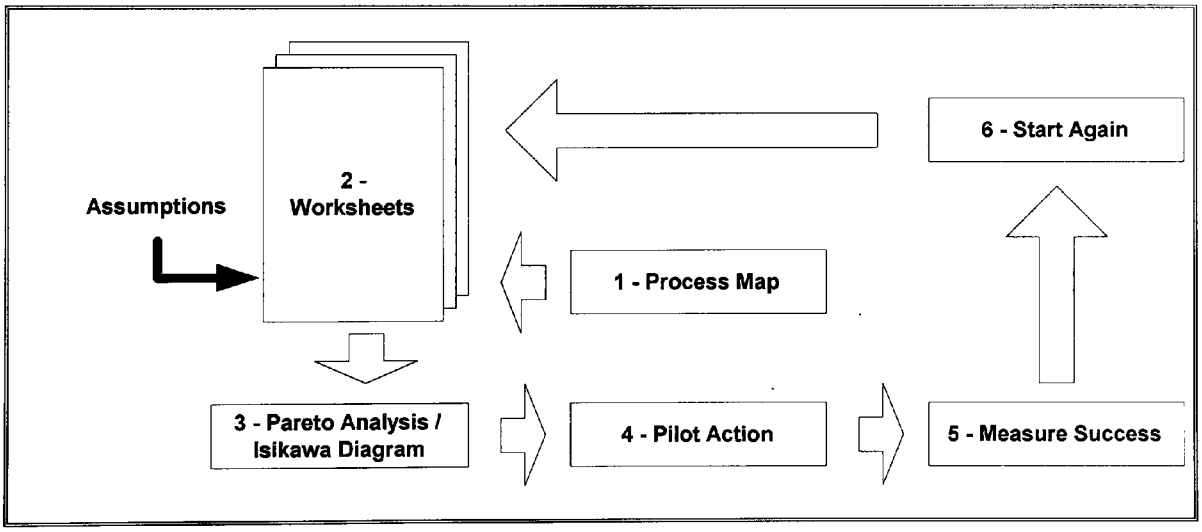
5.2.2 - The Application of a Waste Minimisation Methodology

Following the scoping study, eight students from the University each undertook a six week placement at a SME. In this placement they were asked to follow a waste minimisation methodology.

The methodology described here had, as a basis, the Good Practice Guide (GG38) *"Cutting Costs by Reducing Waste: a self-help guide for growing businesses to improve profitability and assist growth"* (1996) published by the Environmental Technology Best Practice Programme. The author decided to draw upon the methodology developed in this Guide after considering the several

methodologies described under the literature review from Chapter 2. Essentially, all the methodologies described under that Chapter were considered to have common characteristics, and during the course of this thesis it was found that the failure in implementing a waste minimisation methodology was not due to the differences in methodologies but in the internal organisational structures. This waste minimisation methodology was found to be concise, built on previous methodologies, tailored for the SME sector, and previously tested in several companies.

Figure 5.5 summarises the systematic approach adopted for identifying waste by the GG38 Good Practice Guide (1996). Before using this methodology, the students were asked to analyse the culture within the company, since this was seen as crucial when considering implementing a waste minimisation programme.



Source: Adapted from GG38, 1996

Figure 5.5 - The structured process mapping approach

It became apparent during the analysis of literature on the subject (described in Chapter 2) that the greatest effect on the take-up of environmental improvements and the effectiveness of a company's journey towards world class status was its culture. In order to overcome this problem, a company culture matrix was utilised which highlighted the company's present position, goals and means of achieving positive change. The author provides an example of a typical company culture diagram of one of the companies participating in the Environmental

Enterprise Project in Figure 5.6.

The company culture matrix at this stage was seen as a major aspect of the research since it could be used to form the basis of a continuous improvement strategy towards sustainability. It became apparent during the project that waste minimisation could be used as a useful tool to re-engineer a company's internal and external structures with its suppliers and customers.

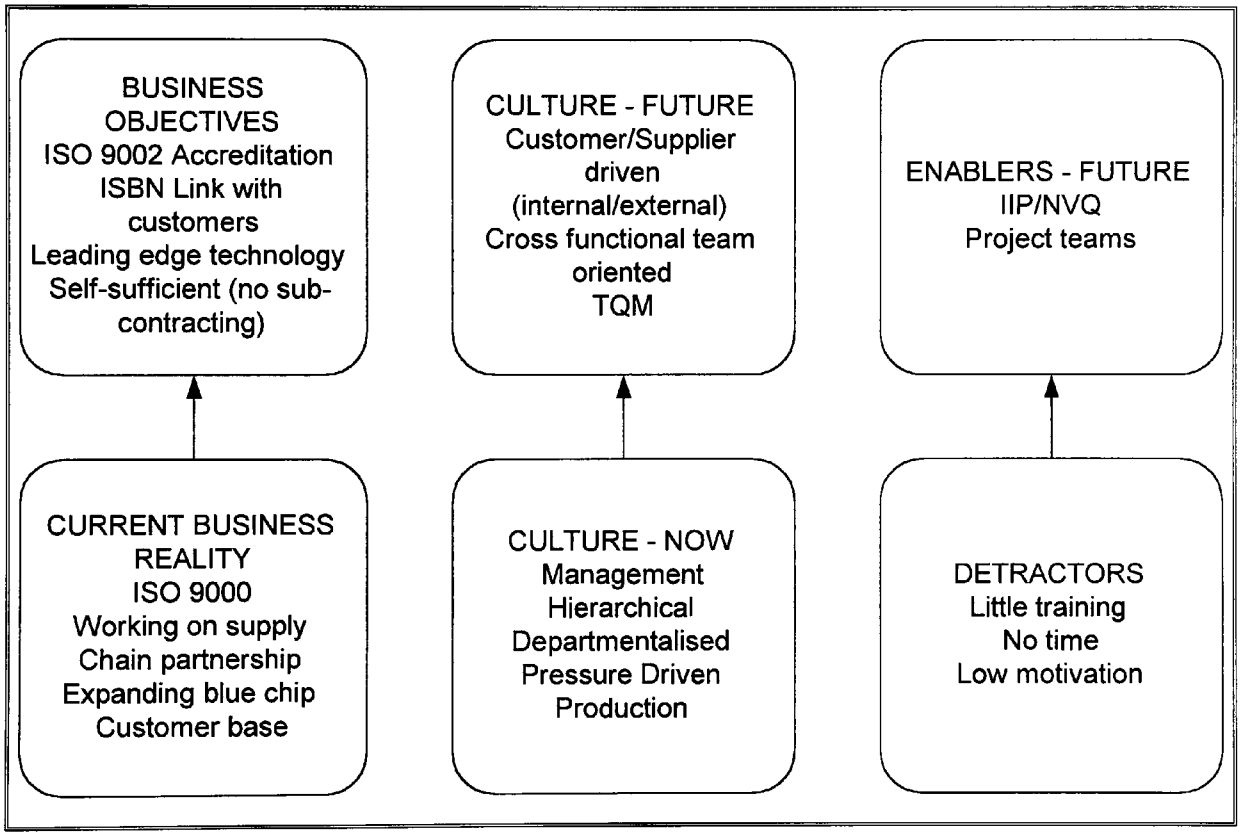


Figure 5.6 - Typical Company Culture Diagram

The analysis of the above information from the *Culture Matrix* allowed the student to have a picture of the current reality of the company and its future plans, as well as current problems that needed addressing under the *"Detractors"* category. Hence, and drawing upon the example given, if one of the detractors was little training, this would affect the implementation of the waste minimisation methodology (since implementation is done by every worker within the company) and thus this would be an area to be addressed in the

action plan.

The following diagram (Figure 5.7) depicts the approach undertaken by the students at the pilot companies.

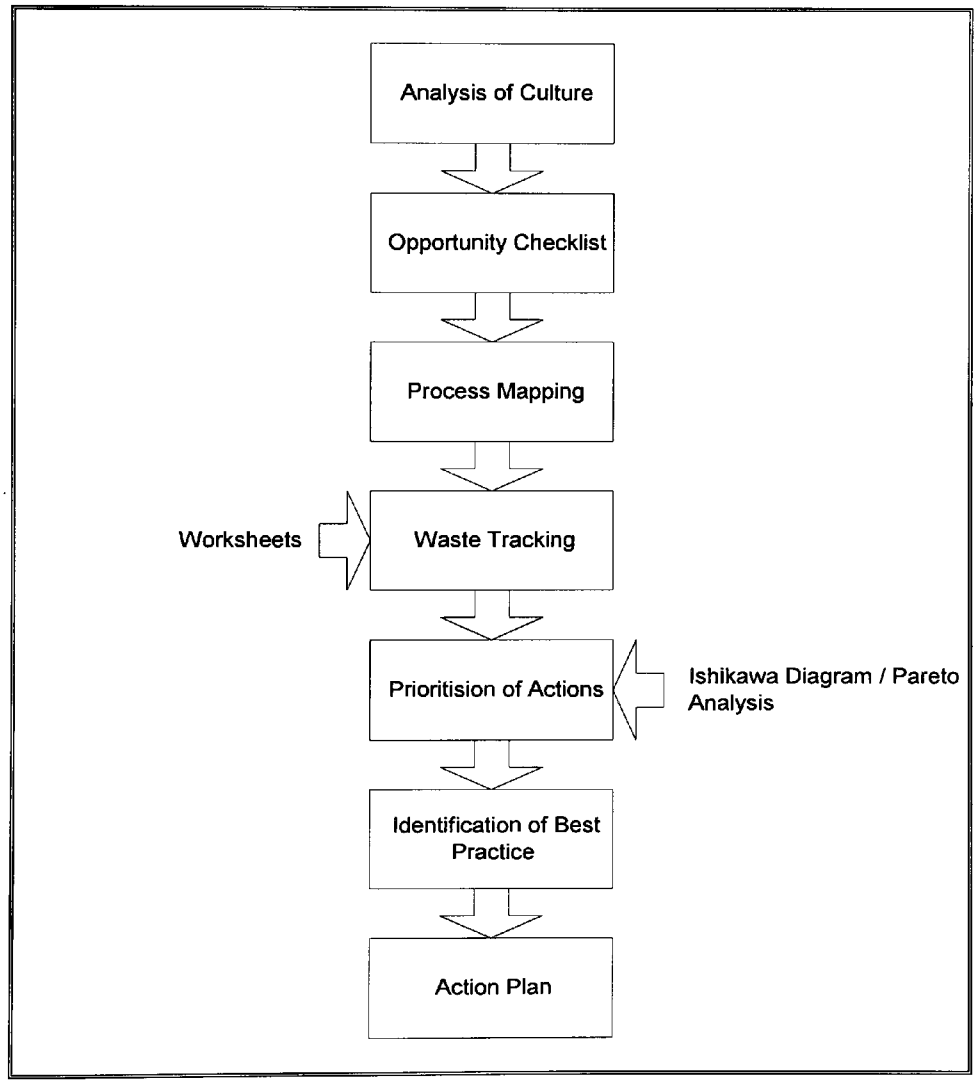


Figure 5.7 - Project Methodology

The methodology is based upon the principle that there is a need to rethink the business operation as a series of separate processes. Each internal process is considered to have its own individual inputs, outputs and waste. Those areas that are outside a process area of

direct control are either suppliers or customers.

The first tool that the student used was *"The Opportunity Checklist"*. This consisted of a series of typical wastes that occur at various stages of a company's activities. When complete, the checklist identifies a wide range of wastes and creates a mind-set which is more open to ideas for changing working practices. This checklist forms the basis for *"quick wins"* to generate immediate financial savings which will ensure management's commitment for the remainder of the exercise.

Another key aspect of the methodology was process mapping. A process is any task or operation that you do to prepare a product for delivery or a service. Each step of a process adds value to a product and incurs a cost from the labour, materials and utilities (gas, compressed air, etc.) used in that process. An example of a process map is given in Chapter 4 (*The Links with Total Quality*, Figure 4.6).

The true cost of waste includes the cost of wasted resources and the cost of rejects at each stage in the process. The cost of rejects includes the value added to the material by the time it is rejected. This means that the cost of rejects increases as the material progresses towards the final product.

Measuring waste and quantifying the real cost of waste is the key output from this element of the methodology. This measurement is obtained through the process map and the completion of worksheets. The procedure creates a mindset where the person uses a flowchart approach of evaluating processes under which the company operates. This waste tracking model is the core of the waste minimisation procedure and is the means by which priority action areas can be identified. Effort must be targeted where it will deliver the greatest financial saving.

Worksheets should be completed for each of the identified processes within the manufacturing or service unit. The summing of costs gives the overall cost of waste to the business.

A clear picture of the *"waste cost"* of the business becomes available. All of the details obtained

during the waste tracking exercise are scrutinised to see if there are any discrepancies in overall values, i.e. between identified and total actual water use, raw material and energy consumption.

Once a priority area has been identified, a *"cause and effect"* diagram can be used to identify the causes and opportunities for eliminating waste within each process. It is crucial to involve everyone, especially *"shop floor"* people, in identifying causes and generating solutions. As part of the action plan, simple measuring systems must be introduced. These must be both cost-effective and appropriate for the process. Decisions on the level of measurement necessary to check on progress must be made, and include regular checks in the plan.

It is essential that measurements are undertaken of existing processes and material or energy use to establish a base line performance. Subsequently the effectiveness of the action programme in terms of savings (time, cost, emissions, etc.) can be quantified.

The cycle can then be re-started to identify the next priority area, which creates a cycle of continuous improvement.

The action plan for the student is depicted in Figure 5.8.

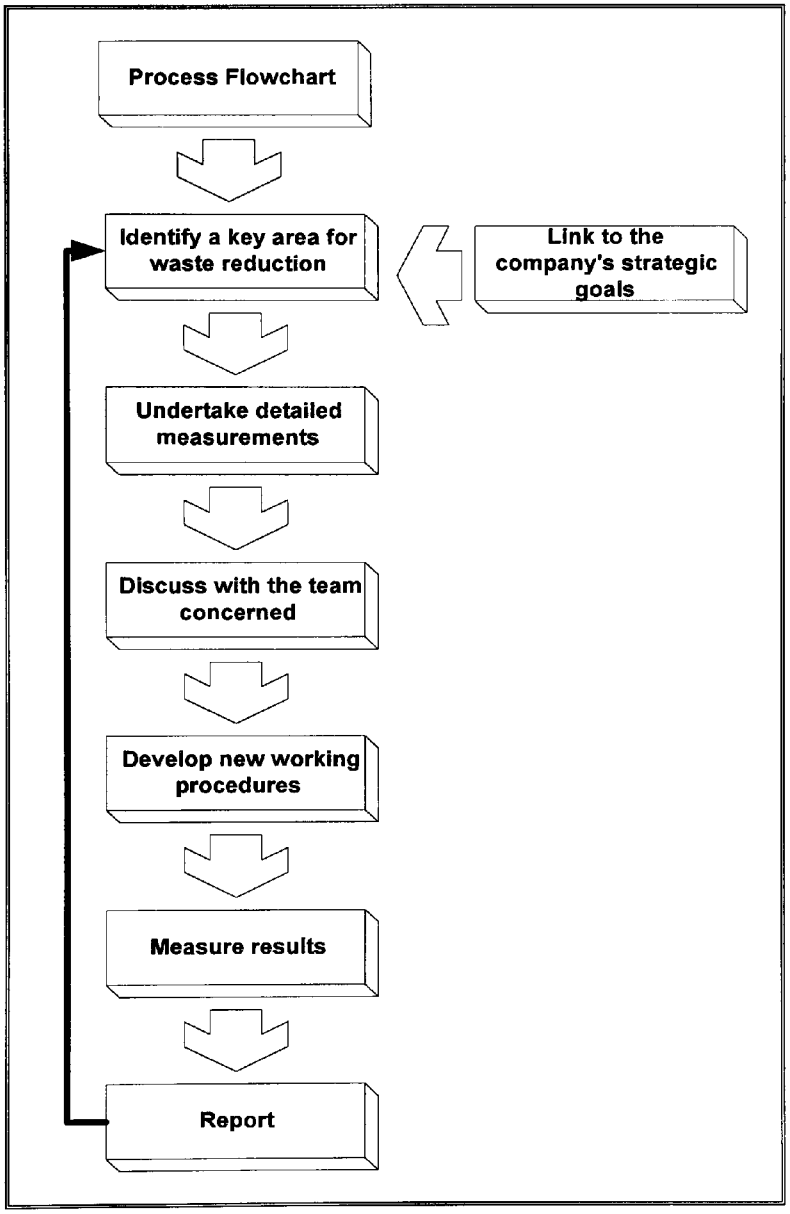


Figure 5.8 - Waste Minimisation - Sample Action Plan

5.3 - The Environmental Mentoring Waste Minimisation Programme

As a result of the work undertaken under the *Environmental Enterprise Project*, another proposal was put forward and supported by an ERDF grant, which gave an opportunity to improve upon the previous methodology. The aim of this *Environmental Mentoring* initiative was to help

substantially improve the competitive position of Small and Medium-Sized Enterprises (SMEs) in Wales by strengthening their capacity for innovation.

The approach adopted in this project at the SMEs is detailed in the Figure 5.9 below.

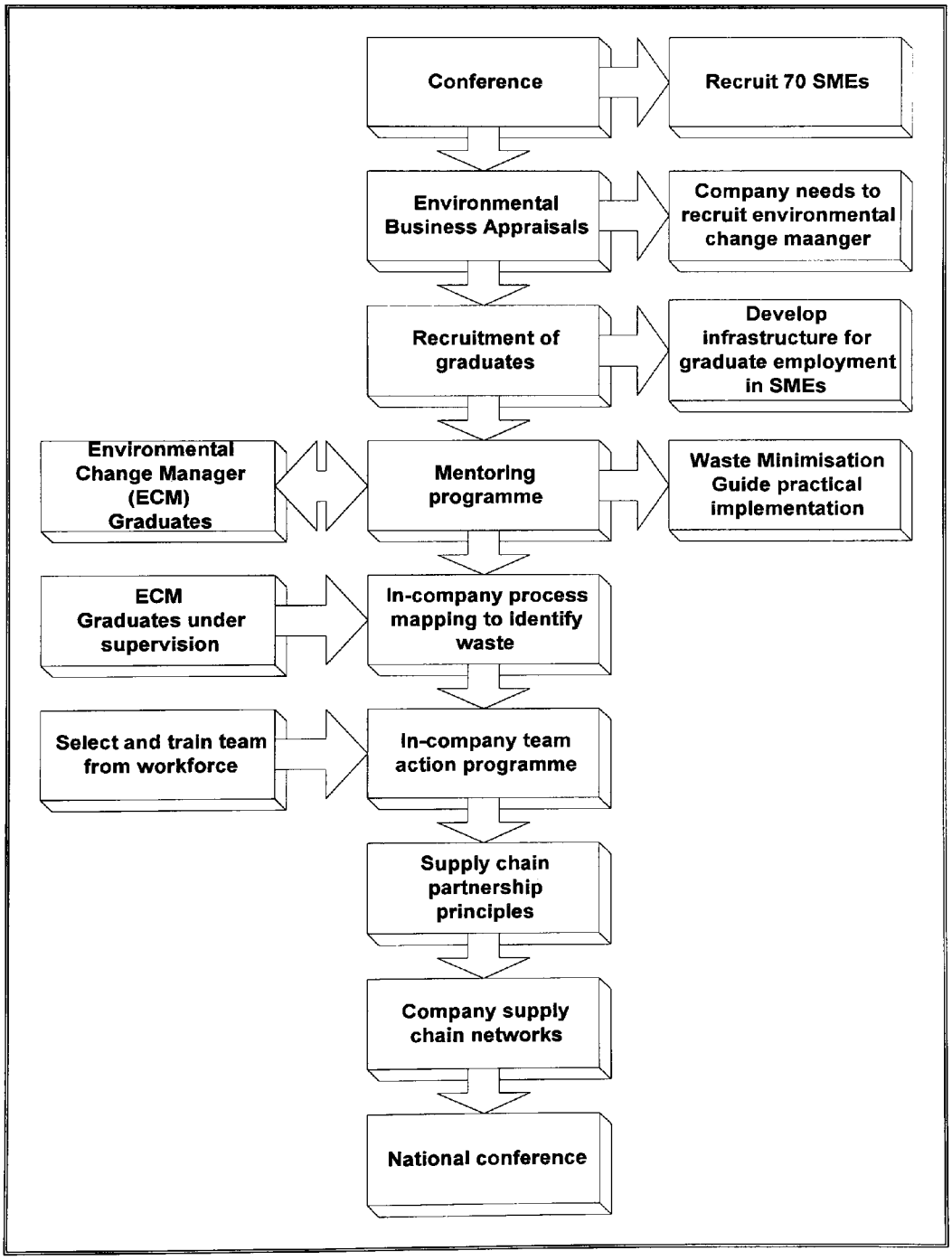


Figure 5.9 - Environmental Mentoring Project Methodology

The objectives of the Environmental Mentoring Project were:

- To create and safeguard jobs through the creation of a self-sustaining continuous improvement culture within SMEs based upon the principle of releasing the creativity of the workforce to improve environmental performance through innovation;
- To raise awareness of business in the region to the new environmental techniques available and to investigate the factors leading to, and inhibiting the take up of clean technologies;
- To assist in improving the performance of the region's wealth creating manufacturing industries towards world class levels;
- To facilitate corporate entrepreneurs to identify waste by re-thinking their processes and to develop value-added goods and services that deliver what their customers require;
- To demonstrate to SMEs the value of employing trained graduates, and thus increasing their employability; and
- To enhance profits for SMEs through innovation and environmental action.

The following is a description of the different stages of the project described in Figure 5.9.

5.3.1 - Conferences

A series of conferences and briefings were organised through the CBI and the WDA at venues in South Wales for company directors to ensure commitment. The objective was to recruit companies for the programme and to secure *"corporate sponsors"*. Corporate sponsors are the people who will ensure that the aims of the Environmental Mentoring Project comply with company strategic goals and provide support during the implementation phase.

5.3.2 - Environmental Business Appraisals

To ensure the success of the Environmental Mentoring Project, an appraisal of current environmental and business performance was undertaken to establish baselines and targets. Measurable targets for cost reduction in accordance with strategic goals were established. This is equivalent to a detailed *"Business Health Check"*. The pilot companies nominated an Environmental Change Manager (ECM) to champion the project. He/She was the person who was responsible for project implementation within the company. This person received mentoring support so that a continuous improvement culture was created within the company as a direct result of the project. The rationale was to ensure commitment to the project from within and make provisions for when the project finished there would be still someone in the company that would strive for change and continue to drive a programme for continuous improvement. This role of the *"environmental change manager"* is best described in Figure 5.10 below.

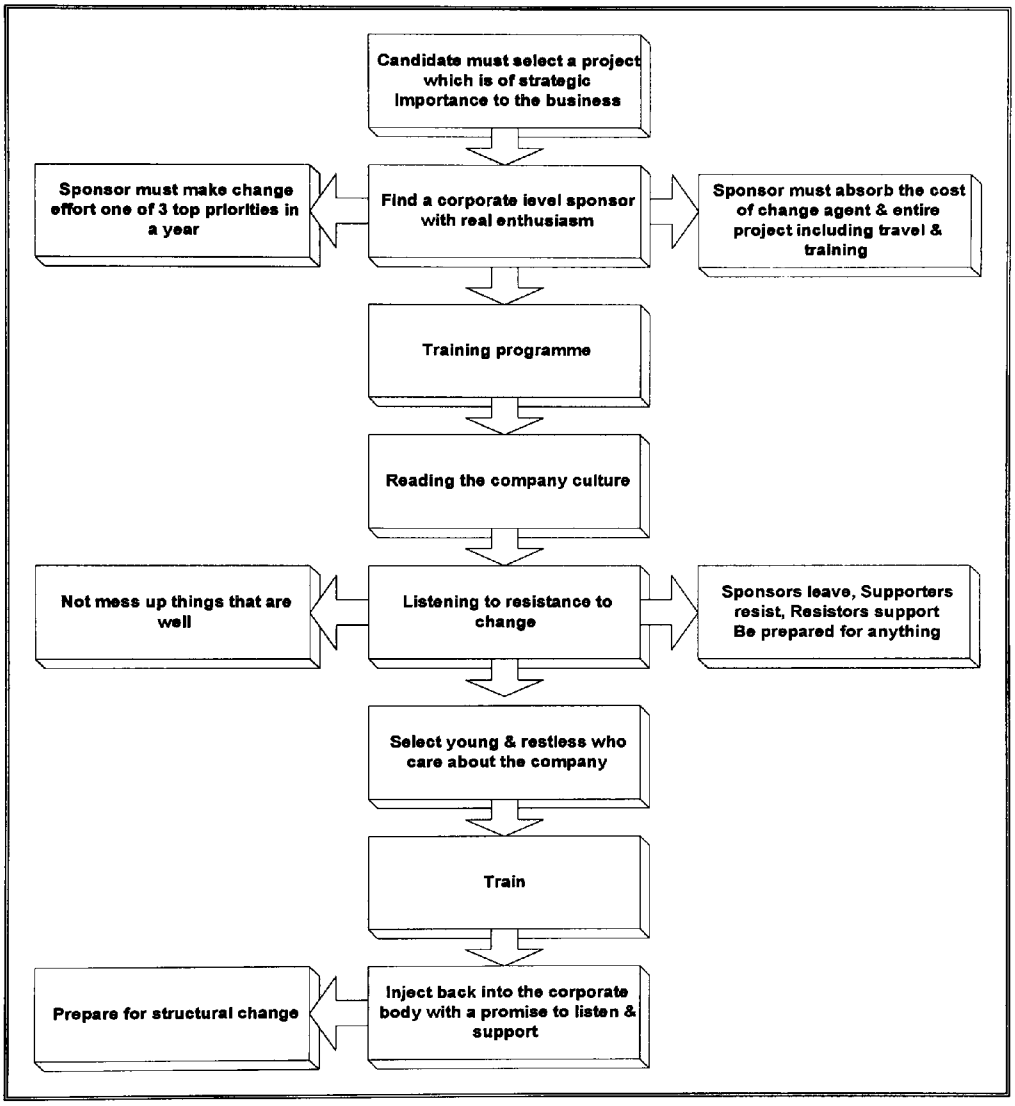


Figure 5.10 - The Environmental Change Manager Role

5.3.3 - Recruitment of Graduates

A key element of this project was to demonstrate to SMEs in a practical manner the benefits of graduate employment., as a vehicle to introduce new ideas that improve business performance. The graduates recruited under the project were carefully selected to ensure that they had the correct enthusiasm, management and technical skills to provide practical value to employers. This aspect supports one of the key objectives of the *Regional Technological Plan*

for Wales by providing graduates to help SMEs with environmental innovation. It also demonstrates that graduate employment can be sustained through the savings generated by implementing effective waste minimisation regimes.

5.3.4 - The Mentoring Programme

This stage of the project was crucial for companies to develop a continuous improvement culture which will act as an *"anti-consultant"* approach, by allowing the programme to be self-sustained after the project finishes. Environmental Change Managers, together with the graduates, benefited from workshops that explained the two factors, which are, according to the author, essential for sustainable success:

- The waste minimisation process mapping procedure
- The management of change which created the culture that allowed the creativity of the workforce to be recognised and their ideas implemented.

Graduates, whilst being trained in both principles, were required to attend specific workshops related to Environmental Best Practice and Technologies.

The Environmental Mentoring Programme undertaken within the companies is similar to the one adopted in the Environmental Enterprise Project, which proved to be the element of success (discussion of project results is undertaken in Chapter 6), and that can best be described under the following steps:

Step 1 – Gathering the Facts – This initial step is where the team decides where the business would benefit from a waste reduction programme. Facts, not opinions, fuel good problem-solving, so this is an opportunity for the team to gather all the relevant data for analysis. Key activities under this step are:

- To produce an overall process map of the company's business;
- To identify and attribute a monetary value to the waste at each process stage;

- To select a change agent; and
- Complete the Opportunity Checklist.

Step 2 – Identify and Select Target Areas – Having produced an overall map of the company's core business processes and all the waste associated with this, the team has to agree on target areas for improvement based upon the degree of influence which they can exert, the customers' goals (internal or external) and the areas with the greatest potential for saving. Key activities under this step are:

- Identify and agree the target areas for improvement;
- Produce a detailed waste tracking model for that area; and
- Identify the needs and goals of the customer.

Step 3 – Root Cause of the Problem – At this stage the team focus upon the problem in more detail by brainstorming all potential causes of waste within the target area. As ownership and action on the problem will soon need to be addressed it is important at this time to identify the Project Sponsor who will lend his/her full support. The team leader and the project team is identified. Key activities under this step are:

- Develop the problem statement;
- Identify the main cause of the problem;
- Liase with the project sponsor regarding the target area; and
- Problem solving training given to all involved.

Step 4 – Best Solutions – Having identified the top 5 causes to the problem, the team gathers further data pertaining to those areas which assist in prioritising action. The team looks at the potential solutions to these problems areas. At this point, it is also important to identify the restraining and driving forces to implementing these ideas, in order to generate actions to deal with any problems that may hamper the project. Key activities

under this step are:

- Gather more detailed information (if applicable) on the target area;
- Undertake the forcefield analysis and develop an action programme to reduce the restraining forces and increase the driving forces; and
- Identify best solutions.

Step 5 – Develop Action Plan – The project team develops the action programme and approves it with the project sponsor. Responsibilities are assigned and implemented. It is crucial here that the team are given the correct resources to undertaken the agreed action. The team will need to monitor and measure progress and undertake corrective action when necessary.

Step 6 – Close the Loop – At this stage the waste minimisation programme is already in place, so this is the continuous improvement stage. As soon as one measure is done, the team can go back to Stage 4 and address another problem identified.

5.3.5 - In Company Process Mapping to Identify Waste

This stage of the project was undertaken concurrently with the mentoring programme, and formed the basis of *"homework"* between each workshop. This stage drew upon the initial approach undertaken in the Environmental Enterprise Project. Process mapping is used to encourage companies to re-think their procedures and develop pollution prevention and cleaner technologies. A crucial stage, found during the Environmental Enterprise Project, is the completion of a waste tracking model which measures each waste stream and places a monetary value on each item. A pareto analysis was then undertaken to prioritise actions and quality management tools were again used to develop systems for control (Chapter 4 provides an overview of the techniques used here).

5.3.6 - In Company Team Action Programme

When a prioritised action programme was agreed upon, a team of front line workers from

the company was trained to develop and implement solutions. Mentoring workshops for the team were held at each site. This was essential for a team-based continuous-improvement culture to be created within the company. The dual benefit of this approach of cost reduction and improved environmental performance also created a readiness within these companies to work towards world-class business status.

5.3.7 - Supply Chain Partnering Principles

One of the key areas for SMEs success is the need to recognise the benefits of supply chain partnering. Many of the wastes identified through the process mapping are created from within the supply chain. WBA have developed a supply chain Mentoring and Supplier guide in conjunction with Nortel Cwmcarn and DoE/DTI over an 18 month period. This guide is based upon re-engineering of the supply chain to reduce waste and develop true partnering with shared savings. Workshops were held for ECMs and the company's purchasing managers to make them aware of the benefits of creating effective supply chain partnerships.

5.3.8 - Company Supply Chain Networks

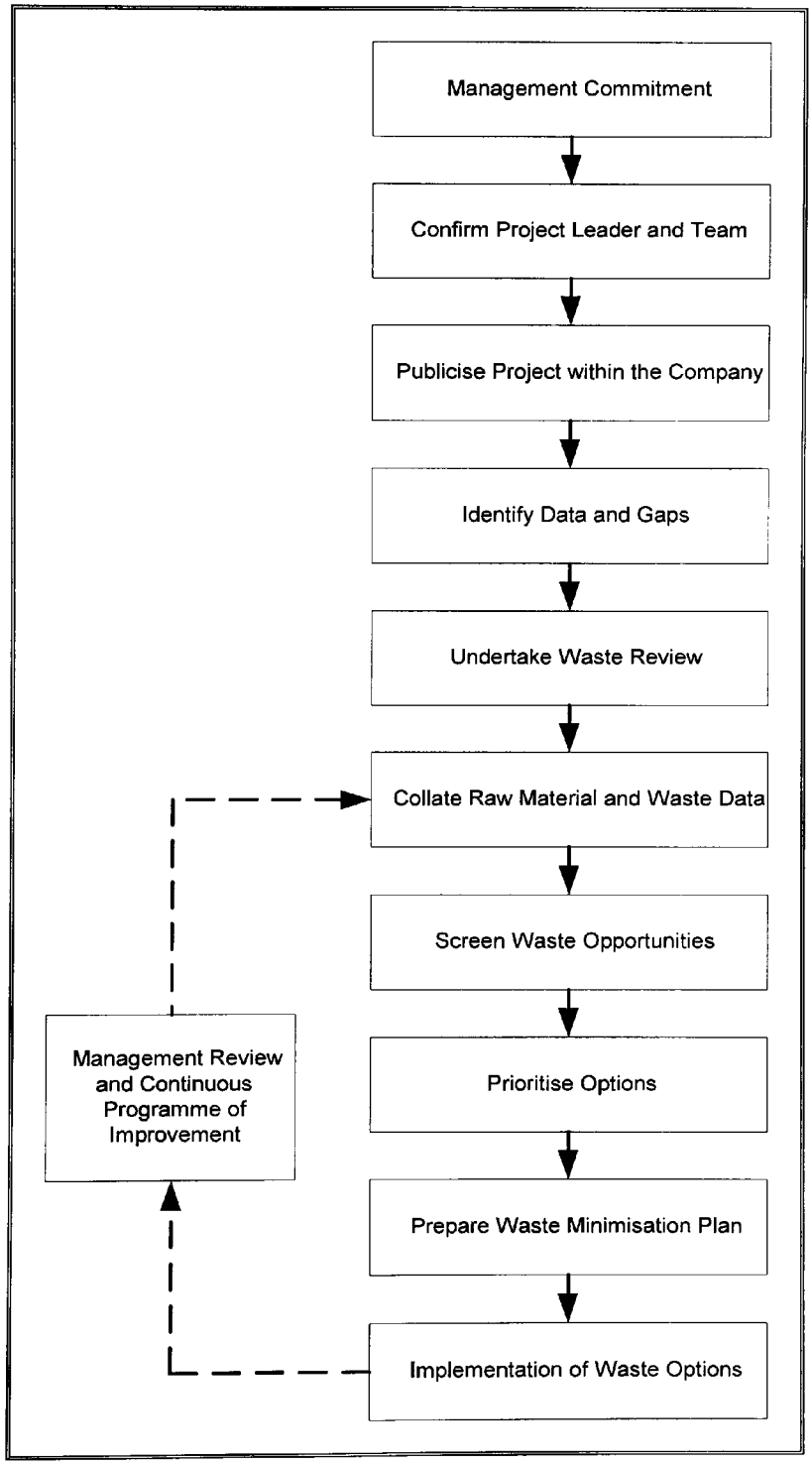
Company supply chain networks were created. Each SME supplier company received a copy of the supplier guides and support to identify synergies of interest that delivered shared cost savings benefits. This aspect of the project greatly assisted companies to provide a foundation of trust for future development. The sustainability of this initiative was assured by working with the WDA and TECs in Wales to provide on-going company support. This provided a real opportunity for showing the tangible benefits to companies who decided to work towards sustainability.

5.4 - Sustainable Businesses in Action (SABINA) Waste Minimisation Project

SABINA (1998) was a project launched in January 1997, in order to address waste minimisation in the Severn Estuary area, including a broad mix of manufacturing sectors. The main objectives of the project were as follows:

- To demonstrate cost savings and environmental benefits;
- To provide practical assistance to companies;
- To facilitate an increase in staff awareness of waste minimisation;
- To identify net environmental benefits and shared savings through positive supply chain activity;
- To achieve demonstrable reductions in consumption of raw materials and levels of waste produced; and
- To demonstrate how effective waste minimisation, waste management, staff awareness and supply chain co-operation can contribute to sustainable development.

The methodology followed by SABINA (1998) is depicted in Figure 5.11.



Source: Adapted from SABINA, 1998

Figure 5.11 - SABINA's Project Methodology

The approach of SABINA (1998) was broadly based on the experience of the project team in a Severn Estuary feasibility study, other industrial waste investigations and the PREPARE project undertaken in the Netherlands. One of the characteristics of the approach of the project considered important by the authors (SABINA, 1998) was the high degree of involvement by the participating companies, achieved by assigning a committed team to co-ordinate waste minimisation on each of the sites and providing continuity throughout the project. Training was another characteristic recognised as particularly important to ensure that the companies developed the necessary skills to maintain environmental improvements after the end of the project.

Key achievements from the SABINA project (1998) have been as follows:

- 200 waste minimisation opportunities have been identified, of these approximately 100 were feasible, with relatively few requiring capital expenditure (20%);
- The total annual savings to the date of the report stand at almost £1.5 million;
- A wide range of supplier-related initiatives were identified, involving a reduction in packaging waste, supplier quality and improved management and segregation of construction waste; and
- Increased awareness of waste minimisation issues.

Two interesting conclusions mentioned in the final report of SABINA (1998), and relevant for the purpose of this research, were:

- Firstly, the project had assisted in developing a gradual culture change in participating companies which had been illustrated by the involvement of managers and employees not previously associated with waste minimisation. This conclusion supports the issues addressed by the author, when she states that waste minimisation is both the cause and effect to achieve culture change towards sustainable development.
- Secondly, it was mentioned that a shorter programme with practical site assistance given by graduate facilitators would have received wider support from SMEs. This is

also a concern of the author in both projects in which she has participated.

5.5 - Aire and Calder Waste Minimisation Project

The Aire and Calder project[11] was launched on 25 March 1992. This programme was sponsored by BOC Foundation for the Environment, the National Rivers Authority, Yorkshire Water and HMIP. The project involved 11 companies, in a co-ordinated effort to reduce waste. The total project costs were £400,000. The participating companies are listed in the Table 5.1 below. The methodology used in this scheme was based on the US EPA Guide to Waste Minimisation (1988), the UK Institute of Chemical Engineers (IchemE) Waste Minimisation guide (1995) and the project manual produced for the Dutch PRISMA scheme.

Companies Participant in the Aire & Calder Project	
British Rail	Horsell Industrial Graphics
Coca-Cola / Schweppes	Lambson Speciality Products
Croda Colours Ltd	Rhône Poulenc Chemicals
Crystal Drinks Ltd	Spring Grove Services
Dupont-Howson Printing Systems	Warwick International Specialities
Hickson Fine Chemicals	

Source: *Adapted from March Consulting Group, 1994*

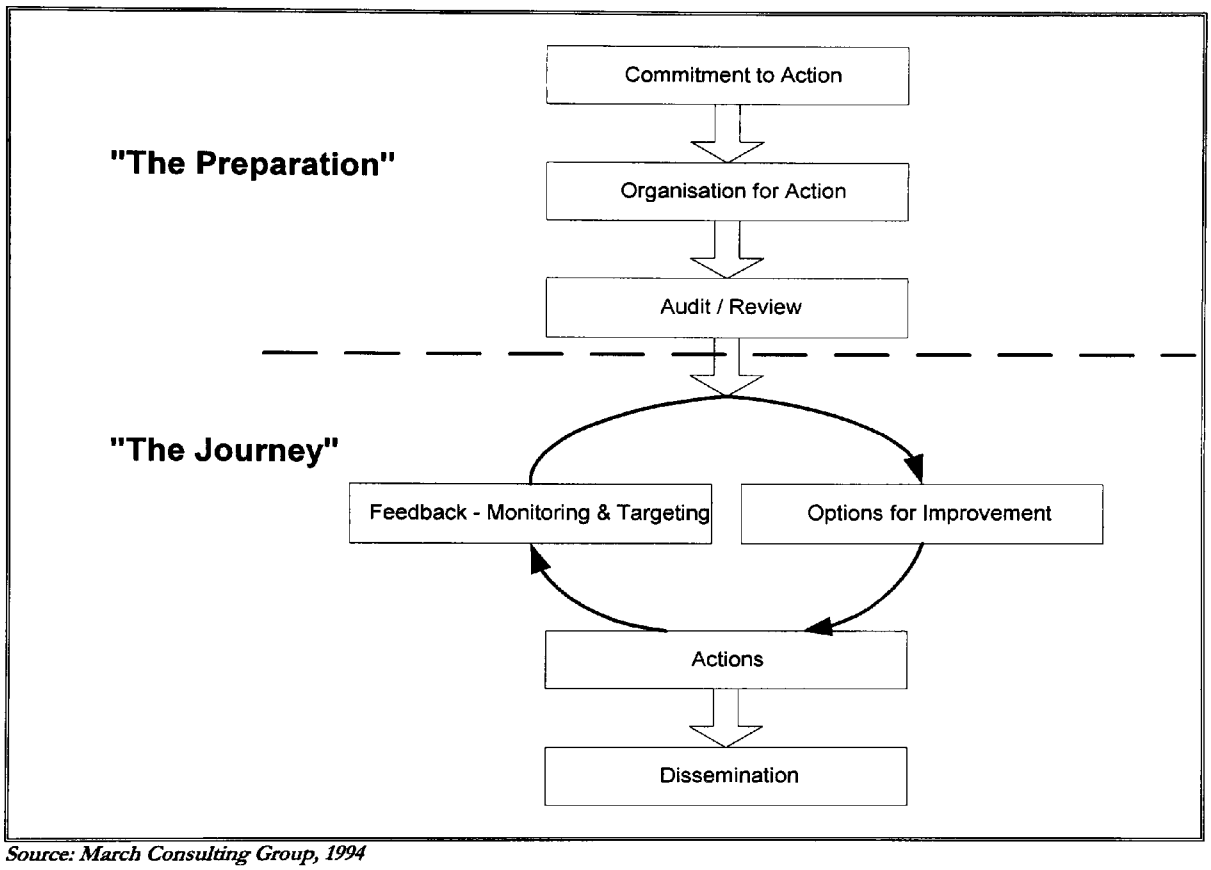
Table 5.1 - Companies participating in the Aire & Calder project

The primary objective of the project was to demonstrate that a systematic and fundamental approach to pollution control pays dividends in the long run. Other objectives included:

- To demonstrate the benefits of a systematic approach to emission reduction,
- To focus on procedural changes and cleaner technology,
- To collect accurate data on costs and benefits, and
- To examine the utility of the IChemE waste minimisation manual in practice

[11] Information contained in this section was taken from the Final Report on The Aire and Calder Project produced by Johnston (1995)

The overall methodology of waste minimisation is shown diagrammatically in Figure 5.12 below.



Source: March Consulting Group, 1994

Figure 5.12 - Aire and Calder Project Methodology

Each element of Figure 5.12 can be explained as:

- Commitment to action – the company should have a policy commitment to waste minimisation as a fundamental component of its environmental policy. In common with other key facets of performance, overall objectives and strategies with timescales for achievement should be specified.

- Organisation for action – waste minimisation assessment and evaluation will embrace many functions within an organisation. Therefore, a cross-functional team should be established to investigate all of the areas of activity of the company and identify scope for improvement in performance.

- Audit/Review – an initial audit and review of all areas of operation must be conducted to provide the base information from which improvement actions can be determined and implemented

- Options for improvement – selection of priorities through technical feasibility and economic viability

- Actions – implementation of improvement plans

- Feedback – continuous monitoring and review

- Dissemination – publicising success to all stakeholders

Within two years of the project's start, 542 measures to reduce emissions and reduce waste had been identified and 150 had been adopted, resulting in savings of £2.1m per year.

Source	Savings achieved to (£'000 pa)	31/8/93 (%)	Savings achieved to (£'000 pa)	31/8/94 (%)
Water use	185	(9)	512	(15)
Effluent	197	(9)	462	(14)
Raw material	1,308	(61)	1,565	(47)
Energy	112	(5)	327	(10)
Others	351	(16)	484	(14)
Total	2,153		3,350	

Source: *Adapted from March Consulting Group, 1994*

Table 5.2 - Savings achieved in the Aire and Calder project

After a further year, 130 additional measures had been identified and savings for the participating companies had risen to £3.3m per year.

According to the authors (Johnston, 1995) the project has clearly demonstrated the environmental and economic benefits of a systematic approach to emission reduction based on the principle of waste minimisation. Additional benefits found were:

- A better understanding of processes,

- Improved product quality,

- Opportunities for new or modified products and processes
- A better working environment

5.6 - Project Catalyst

This project, the largest completed to date in the Mersey Basin area (UK), commenced in December 1992 with funding from the BOC Foundation and the DTI. Fourteen companies were involved (see Table 5.3). The scheme differed from the Aire and Calder project in that it examined wastes discharged to air and land as well as to water.

Companies Participating in Project Catalyst	
Borden Decorative Products Ltd	J W Lees Co. (Brewers) Ltd
CMP Batteries Ltd	Lever Brothers Ltd
Colgate Palmolive Ltd	Manchester Airport plc
J Crosfield & Sons Ltd	Milliken Industrials Ltd
D2D ltd (ICL plc)	Pilkingtons Tiles Ltd
Dunlop Ltd	Royal Mail North Wales & NW
H J Heinz Co. Ltd	Stoves Ltd

Source: *Adapted from March Consulting Group, 1994*

Table 5.3 - Companies Participating in Project Catalyst

At the end of the project's 16 month of life, 399 opportunities for waste reduction had been identified, 118 had been implemented and 118 more had been scheduled for implementation.

The projected annual savings from the opportunities identified included 1.9m cubic metres of water, 1.8m tonnes of liquid effluent and 12,000 tonnes of landfilled waste. Financial savings of £2.3m a were expected from measures implemented before the project finished, and schemes due for adoption in the succeeding 12 months were expected to yield a further £3.7m per annum in savings.

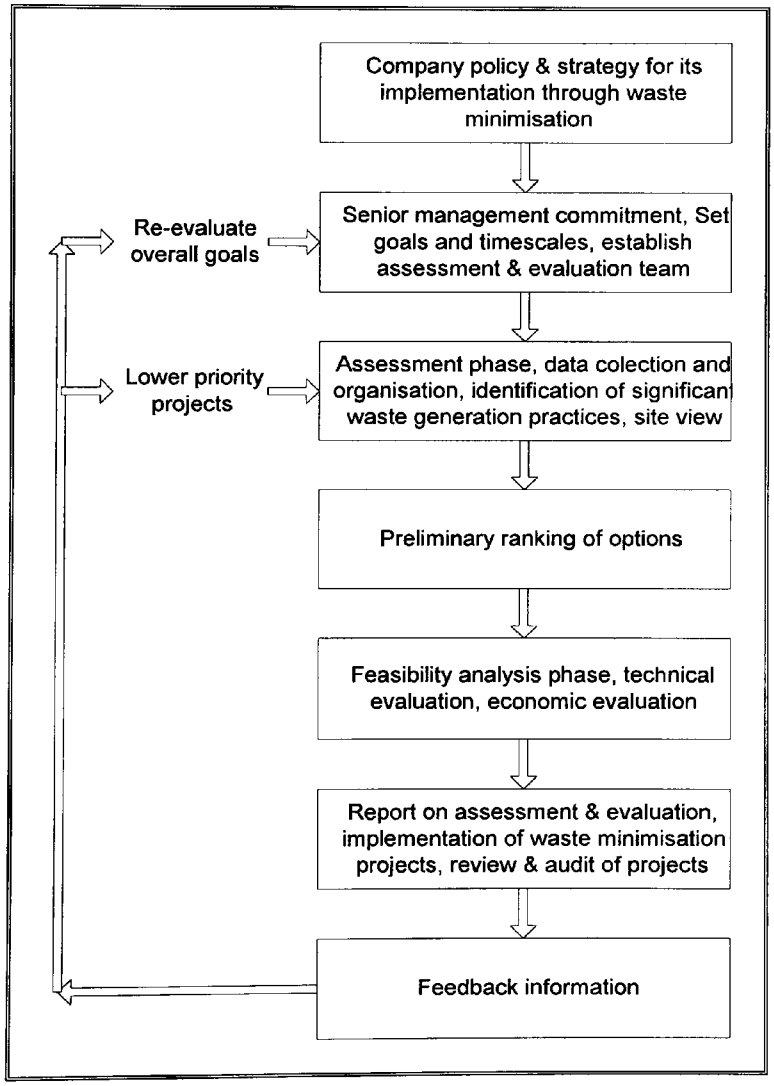
Project objectives included (March Consulting Group, 1994):

- To achieve tangible improvements in waste reduction in the participating companies;
- To demonstrate the benefits of adopting a systematic approach to pollution

prevention using waste minimisation techniques, and to disseminate the results of the project through local, regional and industry sector channels;

- To train the manufacturing companies' management in monitoring and targeting techniques and the methodology of pollution prevention in order to ensure ongoing improvement.

The project's methodology is depicted in Figure 5.13 below.



Source: March Consulting Group, 1994

Figure 5.13 - Project Catalyst Waste Minimisation Methodology

According to the authors of Project Catalyst (March Consulting Group, 1994), the results from the project demonstrated the success of applying waste minimisation techniques to a wide range of industry and commerce. Key factors emerging as essential to the success of the programme were:

- Commitment from the top;
- A structured approach;
- Involvement of an adequate representation of total workforce.

Apart from the cost savings identified other results of the project included:

- All the processes studied provided opportunities for reduction at source and recycling;
- The general approach was applicable to any sector;
- Simple solutions to problems could be found from the experience of companies outside their own sector, so there were obvious benefits from networking

5.7 - Summary

This Chapter described the implementation of various waste minimisation programmes in SMEs. Two of the projects were described in great detail since they had the direct participation of the author and consisted in the bulk of the research undertaken by the author. The other projects described here serve the purpose to illustrate work undertaken by other authors in this area. No discussion is undertaken at this stage, since it will be pursued in Chapter 6.

Chapter 6 - The Application of the Methodologies

6.1 - Introduction

In this Chapter the author presents a discussion of the application of the different waste minimisation projects/methodologies described in Chapter 5.

6.2 - Comparison Between the Different Approaches

In order to pursue a complete analysis of methodologies, the author decided to compare the Environmental Enterprise Project with SABINA (1998), Aire and Calder (March Consulting Group, 1994), and Project Catalyst (Johnston, 1995). The terms of comparison used are: methodology, project objectives and outcomes.

The author found that the different projects employed the same basic methodologies and primarily consisted in securing commitment from top management, the setting up of a team, producing an initial review of the companies processes and wastes, setting targets for waste minimisation and reviewing progress. This methodology is employed extensively in quality and environmental management systems.

Project objectives were again very similar and can be summarised as follows:

- Raising awareness within SMEs that waste minimisation is good business practice, besides providing environmental benefits;
- Reducing costs through a reduction in waste and more efficient processes; and
- Achievement of environmental benefits through a reduced production of waste, reduced consumption of raw materials and reduced pollution levels.

As a result of having similar methodologies and objectives, and from analysing the different project reports (SABINA, 1998, March Consulting Group, 1994 and Johnston, 1995), the author concludes that the different projects' outcomes were the same as the ones witnessed by the author when reviewing the performance of the Environmental Enterprise Project (discussed under point 6.3 below).

The outcomes reflected the different projects objectives and were in summary: cost savings and increased environmental benefits. In this respect, the author considers that all projects were successful. Nevertheless, the author argues that waste minimisation is much more, and can achieve a great deal more than this. In order to confirm this, the author refined the methodology used, developed and applied it in the *Environmental Mentoring Project.* The following is a discussion of outcomes achieved within the *Environmental Enterprise Project.*

6.3 - Discussion of the Environmental Enterprise Project

At the completion of the *Environmental Enterprise Project* it was found that the implementation phase was successfully completed with some excellent benefits identified at the 8 host companies. This number of host companies was less than initially thought for the pilot phase of implementing waste minimisation owing to the difficulty experienced in securing commitment from the SMEs. This was identified to be a feature of such projects which especially if reference is made to the barriers described in the previous chapters, reveals that managers working in SMEs still feel that this kind of project is not worth pursuing and is peripheral to their core business.

The average savings identified at each of the 8 host companies was about £30k. A great deal of supervision and group workshops was used to facilitate this part of the project to ensure that the student remained focused on the real issues. Feedback from both the host companies and students alike was very positive. The companies were asked to confirm the savings identified (all did) and whether they would like further involvement in waste minimisation initiatives (all said "yes").

The implementation of this programme proved that waste minimisation could produce cost savings in addition to providing environmental benefits similarly with the other waste minimisation programmes described.

However, a significant development arose as a result of a follow-up into the implementation phase of this project. Despite the savings that were identified (and agreed) at the host companies, six months later very little has been implemented over and above some basic

housekeeping measures. It appeared that the structures within these companies limit the incentive to implement the cost savings. Such barriers within the organisation prevent Environmental (and business) improvement and will obviously hamper the adoption of any waste minimisation/best practice scheme.

It was concluded that although the waste minimisation programme worked in theory and to some extent in practice, it only worked while there was outside *"intervention"*, i.e. within the project timeframe, by the use of consultants and placement of students. Although several initiatives were made in terms of securing top management commitment, providing training in waste minimisation and involving the workforce, within the project methodology, it was obvious that these were not put into practice, similarly with the other waste minimisation programmes described.

After completion of the programme the author revisited the companies and found that, although substantial cost savings had been achieved and hence environmental benefits achieved through the elimination of production waste, several of the skills trained were lost through downsizing. This was due to the fact that there was no real top management commitment for making the project work. The culture remained old fashioned, with strong resistance from middle management, who were allowed to negate some of the culture changes imposed by the application of the waste minimisation programme.

The programme results were actually reduced in terms of long-term effectiveness. Since the *"intervention"* from outsiders in the organisation was terminated, all the hopes for a continuous improvement culture to be established were terminated as well.

6.4 - Discussion of the Environmental Mentoring Project

Arising from the analysis of the results from the *Environmental Enterprise Project* and the other waste minimisation programmes, the author found it imperative to refine these methodologies and improve upon the lessons learned. *The Environmental Mentoring Project* is the result of this. One of the key differences of the *Environmental Mentoring Project* in comparison to other projects is the definition of waste. The primary concern of the project was to

facilitate people within the companies to re-evaluate their processes by identifying waste defined as *"anything that does not add value to the customer"*. In practice, this approach meant that instead of narrowing the vision of people to be process focussed, it enlarged to a company-wide vision. This approach had the additional benefit of encouraging companies to get nearer to their customers and release the innovation potential within their supply chains both to reduce costs and develop new products and services.

Another key feature of this project was that it focussed upon the need to facilitate employees to find their own environmental solutions, in order to deliver financial savings, rather than relying on outside *"intervention"*. This greatly assisted in promoting the implementation of recommendations, which have been a major stumbling block with previous initiatives. The previous ERDF project discussed earlier has unfortunately proved that the implementation of a waste minimisation programme *per se* is not sufficient to lead companies to improved sustainable environmental and business performance. The mentoring approach ensured that recommendations were implemented. This proved to senior management that savings can be achieved by involving and training the workforce.

An additional feature of this project was the use of Environmental Change Managers (ECM) in the pilot companies to champion the project. The ECM was the person who was responsible for project implementation within the company. The result of having such a person was to create a culture of continuous improvement within the company. The rationale was to ensure commitment to the project from within and make provisions for when the project finished that there would be someone in the company that would strive for change and continue to drive a programme for continuous improvement.

Other outcomes of the project included:

- Increase in profits - These initiatives have shown that profits are boosted typically by 20% through the effective implementation of waste minimisation regimes. The use of the programme has demonstrated to companies that their waste costs are ten times their original estimate. This has focused the mind of managers but has also shown the need for additional resources in order to implement the recommendations.

- Culture change - Environmental action can be a major driver for change by releasing the creativity of the workforce.

- Reduction of environmental impacts and liabilities.

Besides the differences already highlighted in this programme, another important aspect was to address the problem of the internal structures of the companies that acted as a barrier for fully implementing the waste minimisation programme. The analysis of these internal structures was undertaken by using the EFQM model (an overview of which is presented in Chapter 4). The first task of the ECM was to undertake a review of the company by using the EFQM Assess Rapid Score (ARS) questionnaire. The results of the ARS questionnaire were then translated into issues to be addressed before and during the implementation of the waste minimisation programme and to be the roadmap from the company's current reality to where the company should be heading. Figure 6.1 translates this idea.

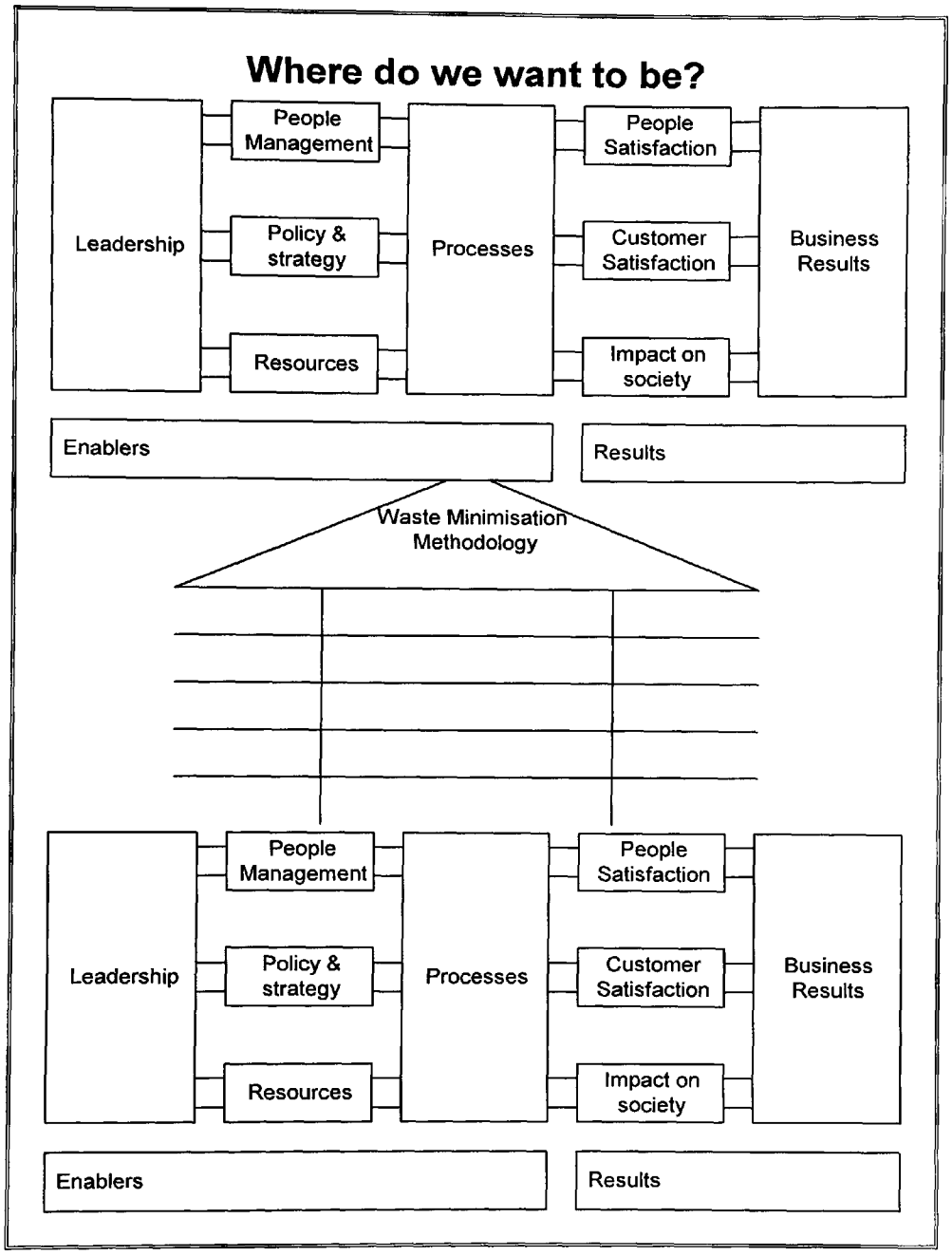


Figure 6.1 - The Analysis of Internal Structures

In summary, the key differences of this project in comparison to other approaches were:

- External consultants acted as facilitators for change, assisted through graduate placement;

- An Environmental Change Manager was used from within the company to ensure that the programme would continue after outside "intervention" ceases;
- Top management commitment was secured by requiring financial support for the project (£10k to join the project) which for a SME is remarkable;
- An analysis of the root causes of waste occurring within the company was undertaken; and
- Waste was defined as anything that does not add value to the customer;

6.5 - Case Studies

The following are two case studies from the Environmental Enterprise Project and the Environmental Mentoring Project respectively. Further case studies of both projects can be found in Appendix IV.

6.5.1 - Case Study from the Environmental Enterprise Project

Company B is a SME, which has grown over recent years to become one of the leading general printing companies in South Wales.

The company was founded in the early 1970s and now provides a quality source for most of the major electronic manufacturing companies in Wales. In the early 1980s, due to increased success, the company relocated to larger premises and has been since relocated after expanding rapidly and efficiently. There are 65 full time employees. Of these, 22 work in the office and the remainder work in the factory/stores. Four machines operate continuously between Monday and Friday on a three 8-hour shift pattern. However, the remainder of the site operates a single shift. The company's annual turnover is £5m.

The company has demonstrated that the need for the integration of Total Quality Management systems into the procedures of the company are important through the recent successful accreditation to ISO 9002. The next step for the company was to build upon this

achievement still further by integrating Total Quality into more areas of the company, such as training, health and safety, and waste minimisation.

The waste minimisation methodology, provided by participation in the *Environmental Enterprise Project*, involved team-oriented activities with the aim of raising employee involvement, motivation and awareness through empowerment. The net result being employees showing initiative and taking more responsibility for their actions. As part of the *Environmental Enterprise Project* a program of monitoring a single colour printing press has been implemented (please refer to Figure 6.2). From the following information and resultant analysis of the data received a better understanding of the machine in operation can be achieved. This analysis of the micro processes involved in printing led to improvements in the macro environment.

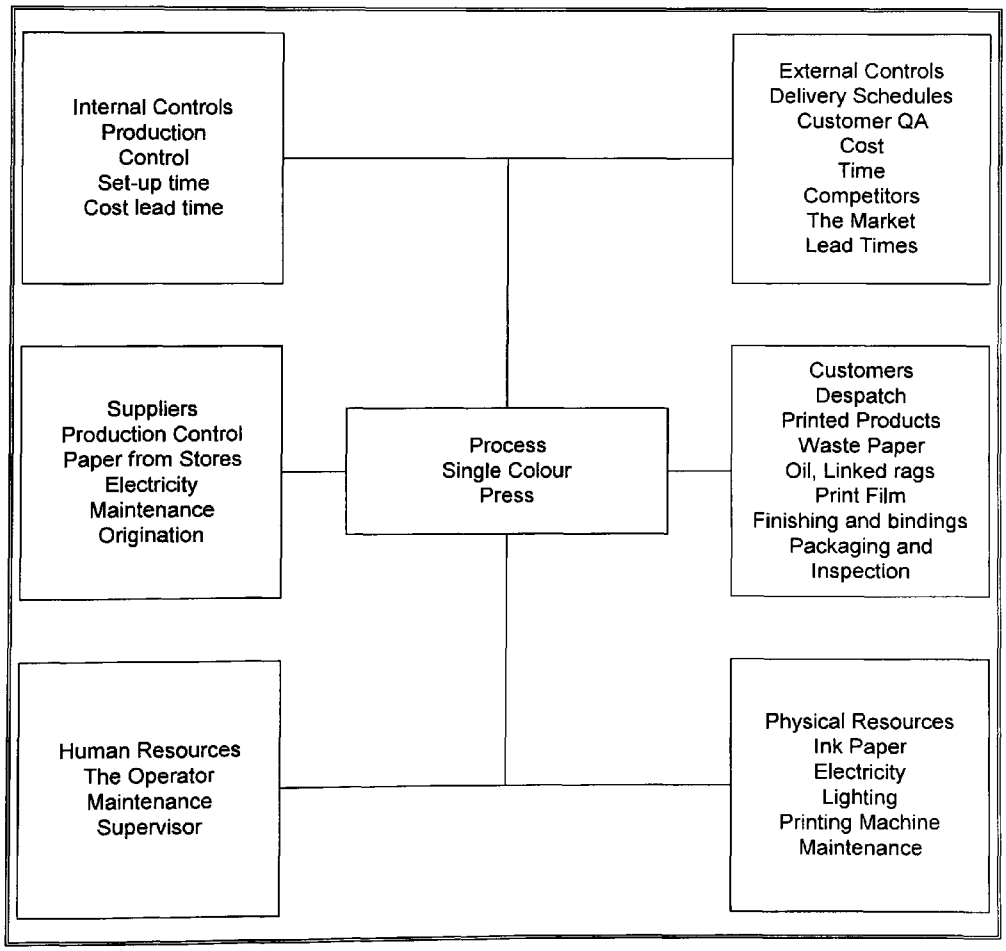


Figure 6.2 - Single Colour Press Process Definition

Proven successful on this machine, the scheme can be extended to other machines whereby the information gained provided a better picture of:-

- *Waste Streams*: Identification of the waste streams which lead to the reduction of waste by the introduction of simple solutions. Less waste, less costs.

- *Trend Analysis*: Identification of the trends within the company, which allowed the company to set clear aims and objectives in fully exploiting these trends to maximise productivity, improve quality and improve profits.

- *Identification of Bottlenecks in the Process:* The identification of bottlenecks within the processes enabled the company to target resources effectively and efficiently in order to remove these obstacles to continual expansion.

- *Process Controls*: Better process controls which enabled the company to reduce waste, improve quality and maximise resource and material and thus reducing costs and improving profits. A structured approach to identifying waste demonstrated to be essential for processes to be understood and the true cost of waste identified.

A recent innovation by the company was the introduction of a company bonus scheme. The scheme is based upon shared profits at the end of six and twelve months with 10% of a fixed target of profits being distributed to the employees depending on their pay band. This type of scheme provides motivation and incentives to improve the efficiency and productivity of the workforce.

The organisation at the moment does not employ waste reduction bonus schemes to motivate the employees to save money through waste reduction. If such a scheme was to be implemented then waste minimisation training of staff would be advantageous.

One of the principal findings of the project was related to lighting. A large proportion of the lighting was not operative and the remainder was largely inefficient and not task-oriented. The most appropriate lighting system would be a scheme involving general illumination at 300 lux and specific task lighting with local control installed over machines. It was therefore recommended that the company should request a free lighting survey from companies such

as Thorn or Phillips and investigate the potential for third party financing and share savings for lighting improvements. There was also the potential to reduce lighting costs by £1,200 per annum which should be recovered within two years and which would reduce defects.

The greatest potential for waste minimisation found lied in the areas of:

- Waiting times
- Incorrect layouts
- High lead times
- Rework
- High stocks and work in progress
- Unnecessary handling
- Material wastage

Packaging waste, such as pallets, cardboard packaging and boxes, was reused, as the process of printing does not alter the shape or size of the product. Printing normally entails a continuous process of printing on paper from one stockpile on a pallet, onto another identical pallet at the other end of the process.

The major significant solid waste was waste paper itself, which comprised of off-cuts, rejects or trimmings. Careful planning of each print job could reduce the waste to a minimum, as part of better quality control.

The recent implementation of Total Quality Systems and the accreditation of ISO 9002, can be seen as a great opportunity to improve effectiveness and productivity through team working. With the continual development of the process of TQM, increased savings through saving on wasted time and effort, as well as materials and product damage, will minimise costs and increase profits.

6.5.2 - Case Study from the Environmental Mentoring Project

Company D is a SME company which produces a wide range of immunodiagnostic products. The company currently employs around 250 people and has an annual turnover of £15.5 million. When the *Environmental Mentoring Project* started, the company were reorganising from a laboratory-based facility to a manufacturing-based one. They were also in the process of using principles such as *"lean manufacturing"* which are corporate change programmes that fit in well with the principles of waste minimisation.

An initial relationship-mapping exercise of the operations at Company D revealed a number of *"hot spot"* target areas which were key to the business. Two of those were:

- Materials unavailable for manufacture
- No schedule for testing materials

One of the first actions of the programme was to analyse the current situation in terms of an analysis of possible drivers and detractors for the programme and the use of the EFQM diagnostic. Figure 6.3 illustrates the forcefield analysis undertaken initially, in which it is possible to see the drivers and the detractors for change within the company. Figure 6.4 illustrates the results of the application of the EFQM model in the company.

Drivers →	← **Detractors**
• Good top level commitment • Sufficient resources • Excellent change Agent • A culture of change • Company-wide awareness of waste minimisation • Excellent skill levels through lean manufacturing and six sigma training	• A lot of change taking place • Difficult to know what changes are happening or planned • Root cause of issues is often out of the programme's influence

Figure 6.3 - Drivers and Detractors at Company D

Criteria Name	% = Score / Max[12]
Leadership	55 = 55/100
Policy & Strategy	45 = 36/80
People Management	50 = 45/90
Resources	55 = 50/90
Processes	43 = 60/140
Customer Satisfaction	45 = 90/200
People Satisfaction	44 = 40/90
Impact on Society	43 = 26/60
Business Results	50 = 75/150

Table 6.4 - Results from Using Rapid Assess Score

The following Table 6.5 represents the suggested course of action for the company.

[12] Information on Rapid Assess Score can be found in British Quality Foundation, 1997

Criteria Name	Areas to Improve
Leadership (55%)	Inspire a shared vision, enable others to act, and challenge the process.
Policy & Strategy (45%)	Clarify the mission – why does the business exist? Clarify the vision – where is the business heading?
People Management (50%)	Align the human resources plan with good policy and strategy, develop people's potential to satisfy business needs, and use of people surveys and feedback.
Resources (55%)	Put financial resources to the best use by the use of appropriate technology, ensure everyone has the information which they need, and develop partnering relationships with key suppliers.
Processes (43%)	Identification of key business processes.
Customer Satisfaction (45%)	Identify the customer needs and provide for the right product at the right price at the right time.
People Satisfaction (44%)	Increase people satisfaction by providing for job security, rewards and recognition, involvement and empowerment and teamworking.
Impact on Society (43%)	Improve the impact on society by a better environmental performance.
Business Results (50%)	Improve the business results by creating more value for customers and shareholders.

Table 6.5 - Analysis of Rapid Assess Score Results

The Environmental Mentoring Project acted in this company at different levels. The first was to analyse the internal structures of the company that could act as a detractor for the effective implementation of the Mentoring programme. This analysis provided for the course of action referred in Figure 6.5.

The second was to achieve *"quick wins"* which were considered essential for providing for encouragement and motivation to proceed to a continuous improvement programme.

At company D, the first quick win achieved was related to the use of animal-derived plasmas which were used in many of the products. These were traditionally delivered in 3.5 litre containers in a frozen condition. Once thawed, they could not be refrozen. Most of the

formulations requiring plasmas were made in batches of a size validated by the regulatory authorities. A mismatch between the process volume requirement and the delivery container volume would lead to a significant amount of unused plasma being disposed of.

In order to solve this problem, the environmental mentoring team decided to optimise the container delivery size for plasmas to minimise waste and lower costs. The action was to employ a database of plasma used and container delivery size to determine the optimum size and resultant savings. As a result of this, the supplier was requested to move from a 3.5 litre containers to 1 litre containers. The results of this were:

- Savings of £45k per year;
- Reduction in plasma waste by 460 litres per year;
- 10% reduction in volume handles;
- 8% increase in unit selling price for supplier;
- Consolidated supply base to single source; and
- Extended supply contract to 2 years.

At this moment at company D, although the graduate placement is already finished, the waste minimisation programme is still considered to be in a initial stage. With the role of the ECM and a trained and motivated workforce, new projects are emerging continuously to minimise waste and unnecessary costs.

6.6 - Summary

This Chapter provided a description of outcomes of the different projects. The author shows that all the waste minimisation projects to date where only successful to some extent, namely in achieving cost savings and providing environmental benefits. It is argued during the course of this thesis that waste minimisation is more than that, and the author shows this through including changes in the initial methodology from the *Environmental Enterprise Project.* These

changes were related to the analysis of the culture and internal structures of the companies at the front end of the methodology.

Chapter 7 - Critical Success Factors

"Today's problems cannot be solved by thinking the way we did when we first created them." (Albert Einstein)

7.1 - Introduction

Arising from the development and testing of the different waste minimisation methodologies, it became apparent that waste minimisation programmes would not work unless the structures of the companies where these are to be adopted are examined in the first place.

This analysis is undertaken in order to provide for the setting up of structures, which will allow the waste minimisation methodology to be employed without resistance. So, although the methodology is basically the same for all companies, in spite of size and sector of activity, the methodology has to be tailored to each individual company.

The most common Critical Success Factors (CSF) encountered during the testing of the methodology represent the bulk of this Chapter and, according to the author, can be considered as *"key"* for future sustainable practice. Before proceeding, the author considers it important to mention once more what waste minimisation is about. The points below are based on the findings from the analysis of the participation within the two different projects, and also from work undertaken by other authors. The author argues that waste minimisation relies on:

- Simplifying the manufacturing process – rethinking your process (why are we doing things the way we are);
- Building upon and increasing skills of all employees;
- Maintaining and improving product quality;
- Reducing working inventory – to allow waste to be visible, hence easily eliminated;
- Being customer-focussed – after all he/she is the reason for us to be here in the first place (are we giving him/her what we want at the price he/she is willing to pay for

it?).

- Continually improving in a *"loop system"* (i.e. keep going back and do it all again).

7.2 - Waste Minimisation as the Vehicle for Managing Change

"For today's managers, change and challenge are the order of the day. The pace is such that, for many, the situation appears way out of control. The response of some is to seek to return to rigid control systems, but, like it or not, with the competition after us at every turn, future survival will depend not on old but new ways of thinking and new organisational forms".

Ken Lewis and Stephen Lytton in *"How to Transform your Company and Enjoy it!"* 1997

Before embarking upon analysing the critical success factors for the implementation of the waste minimisation methodology, it is important to analyse why companies need to change and how innovative companies work. This is also because the author postulates in this thesis that waste minimisation is the vehicle for culture change towards sustainable development.

Change, just like waste minimisation, is not a short-term quick fix; it works from gradual steps within a journey that takes forever. Figure 7.1 below depicts the journey for change developed by the author and applied in the Environmental Mentoring Project host companies, in the process of implementing a waste minimisation programme.

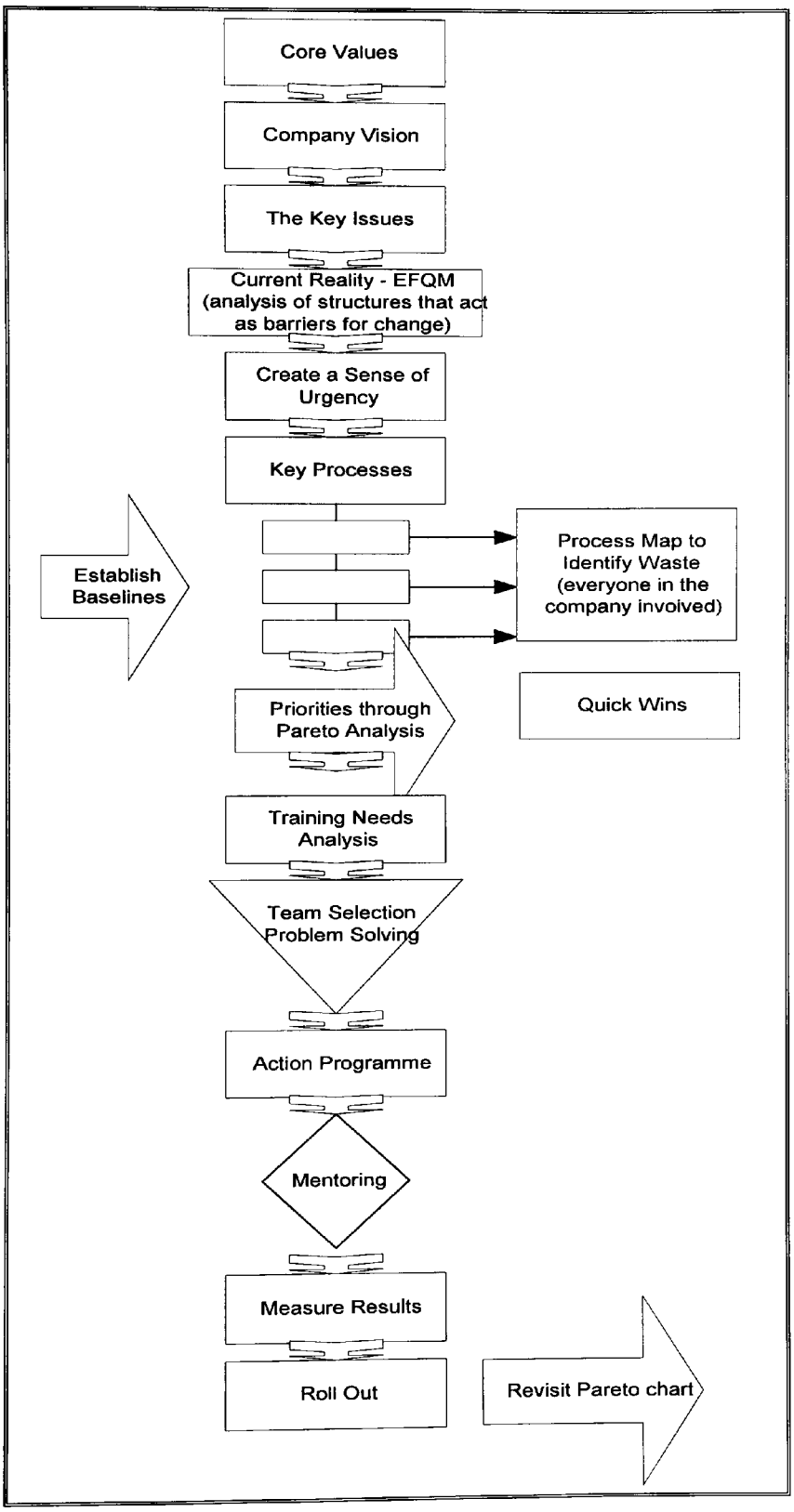


Figure 7.1 - The Journey for Change

The results of the testing of the waste minimisation methodology have clearly shown that the solution lies in the constant reduction of waste: wasted time, wasted materials, wasted effort, while lifting quality and performance levels. Nevertheless, it has also proved that the continual and unceasing reduction of waste can only be achieved and sustained through the elimination of the barriers and controls set by management and current ways of thinking.

The focus of the change should then be on changing the traditional attitudes and control systems held by management, breaking down the barriers and unleashing the potential of each individual employee. The author argues that this waste minimisation methodology is both the cause and the effect of change, i.e. for establishing the programme change is necessary, but by installing the programme change will be achieved.

As previously cited throughout the course of this thesis, every time such a programme has tried to be implemented, the results were unsatisfactory in terms of implementation (refer to literature review in Chapter 2 and discussion of results in Chapter 6). This happened because the initial step for the programme, top management commitment, although quoted in different methodologies, was not achieved. This is the initial change required to establish the waste minimisation programme. When the programme is established then it moves to be the vehicle for more change to happen, and to support the sustainability of that change. Top management commitment is then considered to be the first of the critical success factors for waste minimisation.

In today's competitive environment, most companies aspire to achieve world class status to assure that they remain in business. In their book on how to transform organisations, Ken Lewis and Stephen Lytton (1997), quote Cranfield University's definition of a world class manufacturer. Below are the common points the author found between that definition and waste minimisation, in order to see how the two go hand-in-hand, and to show that, by embarking in a waste minimisation programme, companies are working towards world class.

Cranfield University's definition of a World Class Manufacturer in comparison with the author's definition of Waste Minimisation

World Class Manufacturing means:	It is the author's opinion that waste minimisation:
• Top management commitment to manufacturing as a competitive weapon – which means be committed to use all the resources of the company to beat competition.	• States that everybody in the company should take on board the responsibility of the elimination of waste to drive costs down and increase quality.
• A strong customer focus – which means knowing if you are providing the right service / product to your customer.	• Opposes value-adding activities to waste.
• Awareness of best practice techniques – which means benchmark yourself to the best (not only in your area of work, but to the best company).	• Perfection is the target – the "loop system" – you keep going back and doing it all again.
• Continuous product and process innovation – which means that times keep changing, customer's perceptions as well, excellent companies provide their customers what they want.	• States re-think what you do, ask why all the time, release the creativity of every employee within the organisation.

Table 7.1 - Cranfield University's definition of a World Class Manufacturer in comparison with the author's definition of Waste Minimisation

7.3 - The Critical Success Factors

The Critical Success Factors were found at two levels: - within the companies (e.g. current skills, open culture) and within the methodology, (e.g. broad definition of waste). The following is a report on the key Critical Success Factors encountered, associated with examples from participant companies on the Environmental Mentoring Programme.

7.3.1 - People - Inspire Individual Initiative

"Stimulating ordinary people to produce extraordinary results" (quoted in Ghosal *et al*, 1987).

The focus on people has been evident throughout the text, with the idea that the key to successful change is empowerment and in getting the workforce to comprehend very deeply that they are recognised, respected and appreciated as a very valuable resource by the organisation. It is they who will identify and remove the non-value-adding activities. This is a task that can only be done effectively by the people who play an active part in the day-to-day processes.

The concept is that every employee is an expert in terms of his/her sphere of activity. The task for waste minimisation is then to encourage every employee to come up with small incremental improvements that can be carried out immediately, in order to encourage them to keep doing it. In such a way, waste minimisation liberates employees, and they begin to feel able to participate fully, and became the drive for continuous improvement, which is the greatest source for profitability and success.

Human beings do not actually become superseded and obsolete like technology does (i.e. computers and machinery became out of date within a few years). They are resourceful, versatile, creative and the most important resource within any organisation.

Within the development and testing of the Environmental Mentoring initiative (refer to Chapter 5) *People* was found to be a critical success factor. This occurred at two distinct levels:

- Within the project itself – graduate employment and project managers

- Within the companies – Environmental change managers, top management and workforce

The recruitment of graduates proved to be very positive for both of the projects (Environmental Enterprise and Environmental Mentoring projects, refer to Chapter 5). They were highly motivated, highly skilled individuals, who wanted to make the programme work. They were expected to face difficult circumstances within the different companies since they were outsiders to the internal organisational structure. The pressures came both from top management – *"no time to loose, keep out of my way"* attitude – and workforce – *"I don't understand what are you doing here, and I don't want you here"* attitude. People are very resistant to change, especially because of the fear factor – *"am I going to loose by job over this"*, *"I have been doing fine until now, so I don't need to change"*.

The graduates were a crucial factor to make the waste minimisation programme work, since they were the link between the programme, the workforce, the environmental change manager, top management and the project managers.

Within the companies, it was found that, at the beginning, there was a range of interests between the different people involved. The environmental change manager was crucial since he/she had an enormous task, which was to bring about change. The skills required are those of being a leader, a coach and a facilitator. His/her goal within the project was getting the right teams together, properly motivate them and making them face the same direction towards a continuous improvement culture.

The top management role was to provide support for the project in terms of commitment of resources. People will respect and respond to sincerity. This can only be shown through the commitment of the top management in providing the right resources for the waste minimisation teams to move forward and actually implement the ideas put forward. They could only expect commitment from the workforce if they were committed themselves.

The importance of people within a company is also recognised at other levels and by other authors. The following is a table with a comparison between 3M, known as one of the most innovative companies of our time, and the Norton Company, its arch rival in the abrasives

business, that clearly demonstrates the importance of people.

3M	Norton
Less sophisticated approach. The key is that, by aggressively seeking out technological solutions to customer's needs, the company could create valuable innovations, even on the basis of extremely limited core competencies.	Sophisticated approach. Fashioned, divisionalised structure, innovator in financial control systems and strategic planning systems.
"Organisational climate that stimulates ordinary people to produce extraordinary performances".	Strategy for growth through acquisitions. Driving profitability by monitoring the performance of its strategic business units against defined portfolio roles Tight job descriptions.
"15% rule" allows anyone to spend to one-seventh of time pursuing "bootleg" projects" that might be of potential value.	
"Make a little, sell a little" philosophy reflected the idea that the market was usually a better judge of business potential than management hierarchy.	Elaborate planning process and control systems.
Bottom up on a *"grow and divide"* principle, which allowed divisions to fund individual idea champions whose successful project teams became departments and eventually divisions.	Top down approach in a symmetrical, logical hierarchy of tasks.
Frantic activity and disorganised experimentation.	Rational, logical and neatly organised company, routinely acquiring companies.
Recognition that those closest to the customers or most knowledgeable about the technology were usually far better placed to respond to fast-changing environment demands or market opportunities.	Top management clung to the conviction that it was their job to maintain direct control over their key resources in order to exercise their core responsibility as strategic architects.
Develop self-discipline from ownership.	Command and control approach.
Reports are released simultaneously to managers at all levels within the organisation, top-level executives receive the same format at the same time as those in the individual profit centres.	Information systems designed to serve the needs of corporate-level executives.
Calibrate performance against their most effective peers.	Benchmarking with other companies.
Commitment to turn engineers into managers, and managers into leaders.	
Openness to challenge.	
Tolerance of failure.	

Source: Adapted from Ghoshal, et al (1997)

Table 7.2 - Comparison of an innovative company like 3M and a traditional company such as Norton

From the analysis of Table 7.2, it is possible to argue that there are common characteristics of these institutionalised entrepreneurial practices from 3M:

- Inspiring individual initiative
- To align frontline initiatives with the company's overall direction and to prevent distributed entrepreneurship from degenerating into chaos
- Management needs to reflect its respect for the individual in a supportive culture that is open to questioning from below and tolerant of failure

The points mentioned above echo some of the observations made by the author whilst testing and developing the Environmental Mentoring Project. It is important to note that the secret for 3M did not lie so much in the structures, programs, or incentives that were actually very common with structural characteristics of other companies that have failed to create 3M's powerful and durable entrepreneurial style, but that at the foundation of everything there is a deep, genuine, and unshakeable belief in the ability of the individual.

Another key point to be mentioned about 3M's organisational behaviour is that such decentralisation of resources does not imply that frontline managers have complete autonomy in deciding on the use of resources. There are mechanisms to ensure that appropriate review and approval occurs. An example of that is *"make a little, sell a little"* philosophy that encourages experimentation by reviewing project proposals early and often, then making incremental investment decisions. In short, they have build processes that reflect their belief in the people working in the frontlines and in doing so have strengthening the frontline managers' sense of ownership.

7.3.2 - Value Creation as the Opposite to Waste

Today, customers demand quality goods, delivered on time, and they want continuing cost reductions. The basic idea is that the customer is not willing to pay for poor quality. Quality should be built into the product, rather than defects being inspected out.

Value-adding is the opposite from waste. A value-adding activity is an activity that transforms

raw materials to meet the customer requirements. A non-value-adding activity or waste is those activities that take time, resources, or space, but that does not add value to the customer.

Waste from the customer perspective is something that they are not willing to pay for. Within this, another question arises, which is the concept of cost. The traditional cost concept was that the selling price of a product was costs plus profit, which meant two things – if costs went up, selling price would eventually get higher, or if costs went up, and the selling price remained the same, the profits would come down.

The current concept of cost is that of cost is equal to selling price minus profit. This means that since the customer establishes the selling price, the only way to keep the profits is to reduce costs.

The critical success factor within this issue is that waste minimisation cannot be considered a short-term quick-fix. Otherwise, although achieving a reduction in costs, it wouldn't be sustainable in the long-term. It is imperative to reduce costs and maintain or increase quality of product/service.

This was achieved by using waste minimisation as both a quick fix and a long-term approach towards a continuous improvement culture. The solution lay between starting with *"quick wins"* – solutions that were easily identified and implemented – and moving towards addressing issues such as *"why do we do things to way we do?"*

7.3.2.1 - An Example of a Quick Win

Due to the nature of one of the companies, participating in the Environmental Mentoring Project, 38 different varieties of glass and plastic bottles were used in sample analysis. These bottles were used to collect samples such as water, soil, sludges, and food from clients. As part of the waste minimisation programme, a decision was made to reduce the variety of bottles used and, henceforth, reduce the cost and environmental impact of the bottle operation.

After research was undertaken into the technical viability of reducing the bottle diversity, it

was established that 13 different bottles could be used instead of the previous 38.

Of these 13 new bottles, 6 were glass and reusable, whilst the remaining seven were plastic and disposable. The increase in disposable bottles vastly reduced the costs within the bottle cycle and the bottle identification area. Furthermore, since the supplier collected the new bottles, disposal costs were also cut.

7.3.3 - Waste Defined as Anything that does not Add Value to the Customer

Another Critical Success Factor was the definition of waste as *"anything that does not add value to the customer"*. This definition, in practice meant that instead of narrowing the vision of people to be process-focussed and consider waste as what comes out of processes in the form of scrap and defects, it enlarged to a company-wide vision. So waste can be considered as inefficient processes, rigid structures, ineffective communications, etc.

7.3.3.1 - An Example of Waste Minimisation

At one company, participating in the Environmental Mentoring Project, it was found that much of the waste could be minimised or eliminated by altering the structure of the company to improve accountability, information transfer and pride amongst the workforce. The production department was organised into cells, each cell having it's own responsibilities and targets. The Figures 7.2 and 7.3 below depict graphically this idea.

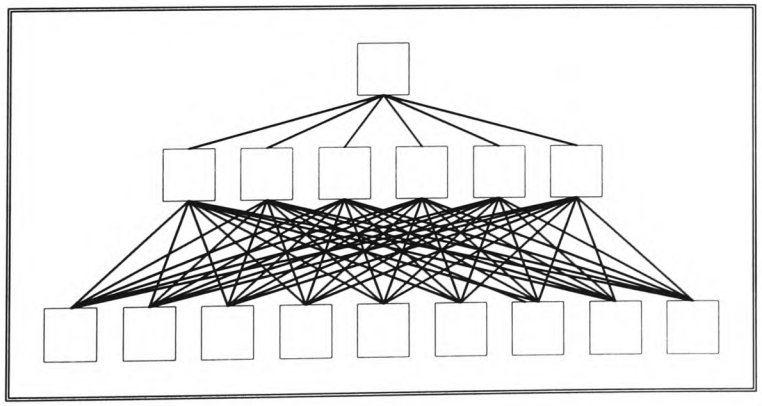


Figure 7.2 - Old Structure

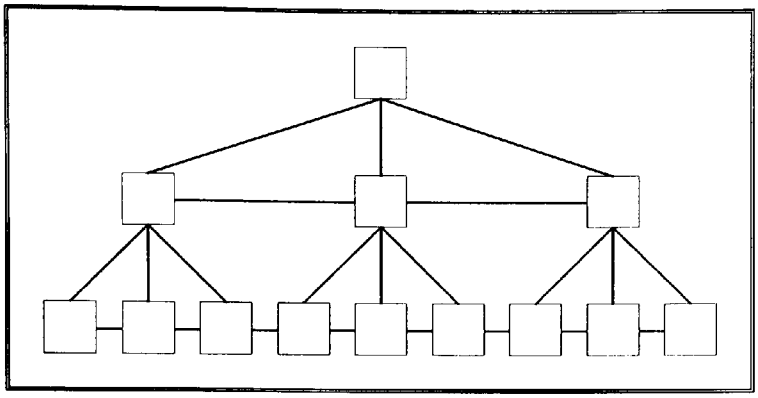


Figure 7.3 - New Structure

This has not only improved productivity and profitability in the short-term but has also encouraged the cells to continue improving their areas. The improvements implemented have also spread benefits to other areas of the company's processes. As an example, as the diagram depicted in Figure 7.4 shows, the improvement made to the structure of the Production department improved the flow of information, the accuracy of the costings, rework, material usage, the time taken to produce products, delivery times, and most importantly customer satisfaction and the overall productivity and profitability of the company.

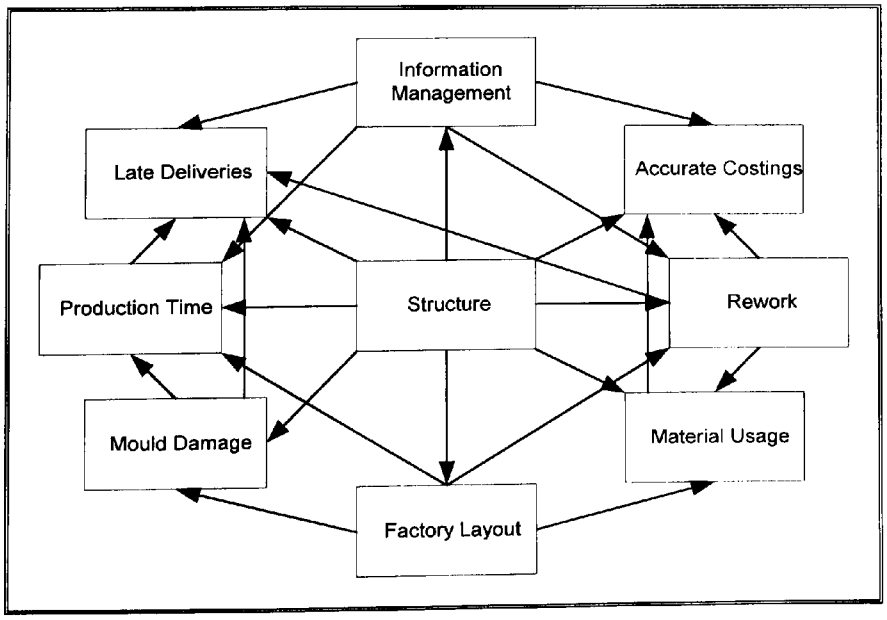


Figure 7.4 - Information Flow

7.3.4 - Re-thinking the Process

Moving from the definition of waste, another innovative concept introduced by the Environmental Mentoring Project was the idea of re-thinking the process. By doing this teams were analysing the relevance of the processes alongside their effectiveness. It is not worth doing something very well if it is not important to our customers and/or they are not willing to pay for it. The following is an example that illustrates this.

7.3.4.1 - An Example of Re-Thinking the Process to Eliminate Waste

At one company, participating in the Environmental Mentoring Project, sample bottles were washed with various solvents in order to prevent oily compounds from sticking to the bottle sides, and avoid contamination when the bottles were reused. This was an area of concern within the company with regard to both the environmental impact and the non-productive use of technical staff.

In order to determine the validity of this procedure, chemical tests were carried out on the different bottles and solvents. After a series of tests, it was revealed that the solvent washing procedure was not necessary in any of the bottles except one. By removing the solvent washing procedure, costs were reduced in solvent purchasing, solvent disposal, solvent bottle disposal and labour.

7.4 - Summary

This Chapter provided an overview of the critical success factors for establishing waste minimisation as a vehicle for culture change. The critical success factors encountered were people, the definition of waste, the concept of value creation and re-thinking the process. The importance of people was that they were essential for the programme at different levels: - top management (to secure commitment), the graduates (to initiate the programme), the environmental change manager (to assure that the programme will be continued), the workforce (to own the programme).

The other key critical success factor was the definition of waste, in achieving culture change, since it allowed the people involved to look at all the issues surrounding the organisation, instead of looking only at the production of waste as the traditional approach to waste minimisation does.

Chapter 8 - Conclusions and Recommendations for Further Work

8.1 - Introduction

Today there are about 6 billion people in the world and the tendency is the world population to reach 10 billion around the middle of this century (WWF, 1998). About 2 billion people live in poverty (as defined in the WWF, 1998). The impact of population growth and reduction of natural resources associated with increased economic activity are set to contribute to unsustainability. The world's economic system evolved in an era of cheap energy and careless waste disposal, when limits were irrelevant. The whole system has to change.

Waste minimisation, pollution prevention and product stewardship can all be classed as sustainable development since all move a company towards sustainability. But, without a framework to give direction to those activities, their impact will dissipate. A vision of sustainability may be regarded as the goal. Sustainability has been defined as the capacity for indefinite continuance (Everard, 2000). For an industry or a company this could be considered a roadmap for the future, influencing the way products and services must evolve (i.e. sustainable development) and what new competencies will be needed to get there.

This Chapter presents the conclusions of this research and recommendations for further work. It is divided between a summary of work undertaken by the author, the contribution to knowledge from the current research, and further work that can be undertaken in order to pursue further the ideas put forward by this research.

8.2 - Summary of Work Done

The work carried out by the author consisted initially of analysing relevant literature. This covered the analysis of the key issues surrounding waste minimisation, such as why people are doing it in the first place, and the work already undertaken in this area. Other literature analysed included information on the SME sector, the pressures for action and the links with Total Quality Management.

The author participated directly as project researcher within two ERDF funded projects. The

work of the author within these projects consisted of:

- Producing a survey of current waste minimisation practices in South Wales' SMEs
- Developing the initial waste minimisation methodology to be used by the graduates at the host companies;
- Establishing the links between the graduates and the project managers, and providing assistance;
- Refining the methodology, during the evolution of the projects;
- Producing case studies from the application of the programme;
- Identifying best practice within the waste minimisation area, and
- Establishing the critical success factors.

8.3 - Contribution to Knowledge

The author believes strongly that what is proved by undertaking this research is that waste minimisation is not a technical quick-fix issue within an organisation but, if correctly applied, is both the cause and effect for a culture change towards sustainable development.

The author has already shown that waste minimisation is about much more than cost savings and environmental benefits. Although other projects have shown that waste minimisation is actually based upon common sense, which is considered accurate by the author, it is put forward in this thesis that waste minimisation can be considered as a roadmap for culture change. Within other projects, it was considered that culture change was necessary to establish a waste minimisation project (by securing top management commitment, and involving the workforce), but according to the author the two issues go together. Waste minimisation is actually the cause and the effect for culture change.

Consider Fig. 8.1, by identifying all waste within a company, it is possible to select several

wastes to start with called the *"quick wins"*, but all wastes are important to identify the *"root cause"* of their existence. There can be countless different types of waste within a company, but by identifying their root causes it was found that mostly there are only a few for all wastes, and these lead back to organisational issues, like systems and culture.

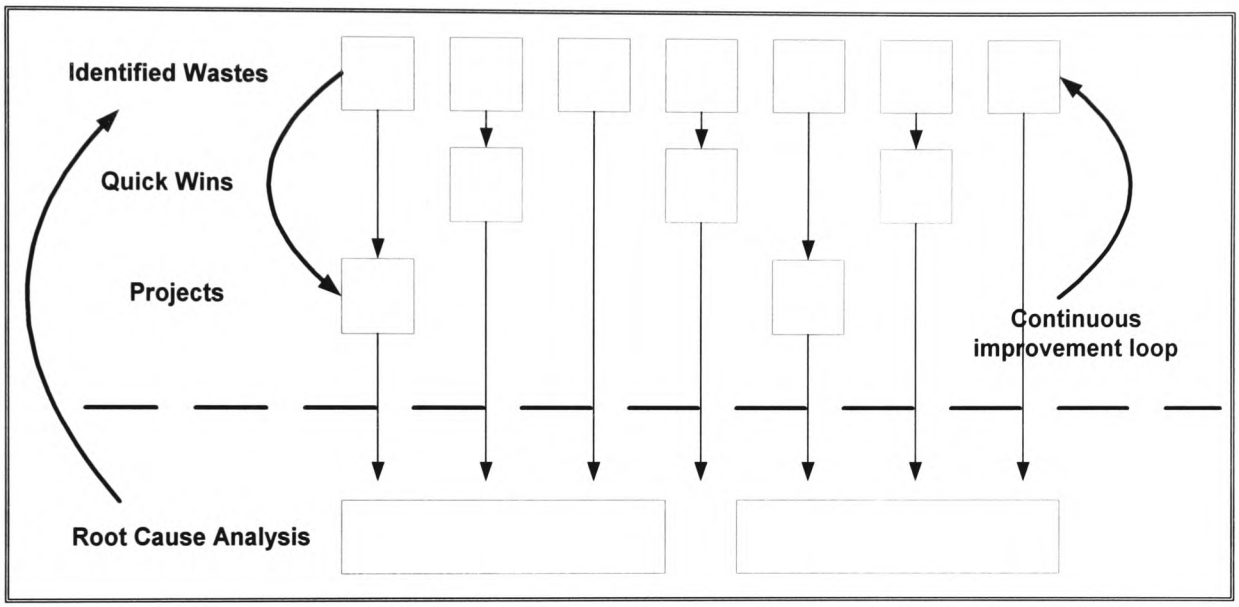


Figure 8.1 - Waste Minimisation as a Road Map to Culture Change

The difference between the methodology developed here, and the work of other waste minimisation projects analysed in Chapter 5, was that they have identified wastes, set targets for reduction or elimination, and continuously revolved on those. The author argues that the only way to make this loop sustainable is to go to the root cause of the problem.

While analysing the root cause of wastes within the *Environmental Mentoring Project*, it was found that these usually were concerned with the organisational culture and structure. These were addressed while pursuing the programme.

Waste minimisation has thus far been considered to be of low importance within a company. Usually, it is at the bottom of priorities, especially for a SME, due of lack of resources. It is only addressed if forced by legislation, or other strong pressures, such as suppliers or customers and other stakeholders' pressure.

By looking at the definition of waste as *"anything that does not add value to the customer"* the author established the necessary links between other areas of the organisation besides the production area. Also, by reviewing the internal structures within the companies, the author secured the success for the waste minimisation programme and addressed the issues other authors failed to address.

The result of a traditional consultancy approach (undertaken by other authors analysed in this work) is an intervention by outsiders into the working practices of a company. It is usually possible to achieve financial savings through a change in working practices in the short-term but, unless a holistic approach is taken, these advantages will eventually be dissipated.

The approach put forward in this thesis is therefore taken at three levels, namely:

- Cost reduction through the identification and elimination of waste;
- Training of a change agent and team to create a continuous improvement structure to deliver on-going cost savings; and
- Recommendations to management regarding systematic change in structures linked to the European Foundation Business Excellence Model.

The difference (novelty) in this approach is that it combines short-term cost savings with the preparation for a deep change programme that leads to sustainable growth. The basis for this approach is the need to develop sustainable improvements that protect jobs by releasing the creativity of the workforce and developing the culture that supports innovation.

The traditional consultancy approach involves the preparation of a management report, leaving the company to implement recommendations. In a large amount of cases, these recommendations are not fully implemented. The research under this PhD thesis used the traditional approach during the first phase to verify the previous statement. After establishing that this was the case the approach was altered and tested in pilot companies. The idea was to work closely together with a company for 6 months to achieve cost savings, similarly with the first phase. At the same time analysis of the structures and current situation within the company was undertaken, so that recommendations for future deep change actions that will

sustain improvements are made in a way that offers the best opportunity for effective implementation.

If businesses can see that their self-interest, in terms of an innovative workforce, improved profitability and new business opportunities, can be satisfied through environmental action then we will have a basis for deep structural change and sustainability.

The development towards a state of sustainability – sustainable development – is today's most urgent priority (Everard, 2000). Within the SME sector, sustainable development can be successfully promoted through rational business logic, which improves environmental performance and reduces cost.

The key findings of this research were that environmental action can be a key motivator for change. Companies that can identify the potential for waste reduction are motivated to initiate changes in attitudes to business process re-engineering. The second key factor was the need to facilitate and train in-company entrepreneurs to develop their own solutions in order to continually improve their business towards excellence.

8.4 - Recommendations for Further Work

The author recommends that further work should be established in order to provide a more accurate picture of the long-term benefits of using this approach, for the local economy. Further work should be undertaken by:

- Revisiting the companies participant in the various waste minimisation projects in the next five years, to assess improvements made in relation to culture change;
- Assessing job creation through the use of graduate placement in such waste minimisation projects;
- Assessing jobs secured through the implementation of the several waste minimisation projects;
- Assessing environmental benefits of the application of the waste minimisation

programmes; and

- Assessing what changes are required to the economic system to promote sustainable development.

APPENDICES

APPENDIX I – EUROPEAN FOUNDATION QUALITY MODEL CRITERIA

Criterion one – Leadership	
Definition	"How the behaviours and actions of the executive team create the culture, values and overall direction required for long term success. These behaviours and actions are appropriately reinforced and deployed by all other leaders within the organisation"
Approach 1a. How the approach to leadership is developed	Areas to address for the organisation could include: 1. defining its approach to leadership including: purpose, direction and objectives 2. integrating the approach to leadership into the overall policy and strategy 3. establishing the organisation culture and driving values 4. stimulating innovative and creative thinking
Deployment of 1b. How the approach to leadership is deployed	Areas to address for the organisation could include: 1. selecting, cultivating and developing leaders 2. structuring leadership across the organisation 3. communicating the organisation's values through: leadership forums, meetings and events
Assessment and review of 1c. How the approach and deployment of leadership is assessed and reviewed	Areas to address for the organisation could include: 1. implementing a monitoring system with early warning indicators and measures 2. identifying and evaluating strengths, weakness, opportunities and threats 3. learning about effective and ineffective leadership (e.g. benchmarking)

Criterion Two - Policy and Strategy	
Definition	"How the organisation converts its overall direction into a clear strategy supported by relevant plans, processes and policies"
Approach 2a. How the approach to policy and strategy is developed	Areas to address for the organisation could include: 1.defining its approach to policy and strategy including: purpose, direction and objectives 2.developing its values, mission and vision 3.developing its overall policy and strategy framework
Deployment of 2b. How the approach to policy and strategy is deployed	Areas to address for the organisation could include: 1. communicating policy and strategy inside and outside the organisation 2. translating policy and strategy into the planning process reaching all levels of the organisation 3. aligning, prioritising, synchronising and agreeing plans targets and actions for teams and individuals in line with policy and strategy
Assessment and review of 2c. How the approach and deployment of policy and strategy is assessed and reviewed	Areas to address for the organisation could include: 1. implementing a monitoring system with early warning indicators and measures 2. identifying and evaluating strengths, weakness, opportunities and threats 3. evaluating understanding, deployment and acceptance of policy and strategy inside and outside the organisation

Criterion Three - People Management	
Definition	"How the organisation develops and manages its people and their knowledge at an individual team based, and organisation wide level"
Approach 3a. How the approach to people and knowledge is developed	Areas to address for the organisation could include: 1. defining its approach to people and knowledge including: purpose, direction and objectives 2. integrating the approach to people and knowledge into the overall policy and strategy 3. defining the processes that generate the key people and knowledge related activities
Deployment of 3b. How the approach to people and knowledge is deployed	Areas to address for the organisation could include: 1. using skill development plans for people to match the capability needs of the organisation 2. sustaining involvement of people for improvement (e.g. appraisal, empowerment and recognition) 3. recruiting new people and acquiring new knowledge
Assessment and review of 3c. How the approach and deployment of people and knowledge is assessed and reviewed	Areas to address for the organisation could include: 1. implementing a monitoring system with early warning indicators and measures 2. identifying and evaluating strengths, weakness, opportunities and threats 3. learning about effective and ineffective approaches to people and knowledge (e.g. benchmarking)

Criterion Four - Resources	
Definition	"How the organisation uses its internal resources (other than people and knowledge) in an integrated, effective and efficient manner"
Approach 4a. How the approach to resources is developed	Areas to address for the organisation could include: 1. defining its approach to resources including: purpose, direction and objectives 2. integrating its approach to resources into the overall policy and strategy 3. identifying key resources
Deployment of 4b. How the approach to resources is deployed	Areas to address for the organisation could include: 1. aligning its resources in the day by day management in supporting of all its processes (process management framework) 2. setting and applying systems standards using tools such as ISO, environmental standards etc. 3. ensuring innovative and creative solutions to resource use and deployment
Assessment and review of 4c. How the approach and deployment of resources is assessed and reviewed	Areas to address for the organisation could include: 1. implementing a monitoring system with early warning indicators and measures 2. identifying and evaluating strengths, weakness, opportunities and threats 3. learning about effective and ineffective use of resources (e.g. benchmarking)

Criterion Five – Processes	
Definition	"How the organisation defines and develops its approach to market and customer and manages to ensure that its products and services fully satisfy their needs"
Approach 5a. How the approach to market and customer is developed	Areas to address for the organisation could include: 1. defining its approach to market and customer including: purpose, direction and objectives 2. integrating the approach to market and customer into the overall policy and strategy 3. defining the key customer focused processes (e.g. production, distribution, sales, after sales, services, etc.)
Deployment of 5b. How the approach to market and customer is deployed	Areas to address for the organisation could include: 1. systematic day to day management of key customer focused processes ensuring they deliver consistent value 2. structuring the organisation and its supply chain to get closer to the final customer 3. resolving interface issues between processes
Assessment and review of 5c. How the approach and deployment of market and customer is assessed and reviewed	Areas to address for the organisation could include: 1. implementing a monitoring system with early warning indicators and measures 2. identifying and evaluating strengths, weakness, opportunities and threats 3. evaluating and improving product/service design processes

Criterion Six - Customer Satisfaction	
Definition	"What the organisation is achieving in relation to its external customers"
6a. Perception measurements	Areas to address could include customers' perceptions (e.g. from customer surveys, focus groups, vendor ratings etc.) relating to: 1.overall image 2.loyalty 3.satisfaction 4.value of products and services 5.sales and after sales support 6.innovation 7.complaints recovery
6b. Performance measurements	Areas to address could include internal measurements used by the organisation to monitor, understand, predict and improve the performance of the organisation and the perception of the external customers: 1.overall image 2.loyalty 3.satisfaction 4.value of products and services 5.sales and after sales support 6.innovation 7.complaints 8.customer facing processes measurements

Criterion Seven - People Satisfaction	
Definition	"What the organisation is achieving in relation to its people and knowledge"
7a. Perception measurements	Areas to address could include people's perceptions (e.g. surveys, structured appraisals, interviews, focus groups, etc.) relating to : 1.motivation 2.commitment 3.satisfaction 4.loyalty 5.communication 6.knowledge
7b. Performance measurements	Areas to address could include internal measurements (early warning indicators, performances, etc.) 1.motivation 2.commitment 3.satisfaction 4.loyalty 5.communication 6.knowledge 7.services provided to the organisation's people

Criterion Eight - Impact on Society	
Definition	"What the organisation is achieving in satisfying the needs and the expectations of the local, national and international society (as appropriate)"
8a. Perception measurements	Areas to address could include the society's perception (e.g. from surveys, reports, public meetings, public representatives, governmental authorities, etc.) of the organisation's performance.
8b. Performance measurements	Areas to address could include internal measurements related to issues listed under 9a as well as other measurements used by the organisation to monitor, understand, predict and improve the perception of society

Criterion Nine - Business Results	
Definition	"What the organisation is achieving in relation to its planned objectives and in satisfying the needs and expectations of everyone with a financial interest or other stake in the organisation"
9a. Financial measurements	Areas to address could include information relating to: 1.profit and loss account items 2.balance sheet items 3.cash flow items 4.share value
9b. Overall measurements	Areas to address could include efficiency and effectiveness measurements of the overall organisation's performance. Areas to address could include measures of performance relating to: 1.market share 2.resources 3.innovation rate 4.learning rate 5.productivity 6.unexploited potential 7.flexibility 8.speed in changing

APPENDIX II – SURVEY

QUESTIONNAIRE

Please complete and return by of to:

Elizabeth Oliveira, (c/o Freepost envelope provided)

Please complete each section in full (please indicate with a tick as appropriate)

SECTION I: COMPANY BRIEFING

Company name: _____

Name of respondent: _____

Position in the company: _____

Nature of business (brief description): _____

Number of Employees:

< 50 ☐ Between 50 and 250 ☐ Between 250 and 500 ☐ > 500 ☐

SECTION II: QUALITY AND ENVIRONMENT

1. Is there a person in your company responsible for quality management? Yes ☐ No ☐
2. Does your company have a written quality policy? Yes ☐ No ☐
3. Does your company have a written environmental policy? Yes ☐ No ☐
4. Is your company registered to BS 5750/ISO 9000/1/2/3 Yes ☐ No ☐

   If yes, when were you registered _____

If no, have you plans to do so in the next:

6mths	☐	12mths	☐
more than 12 mths	☐	not at all	☐

5. Has the company benefited from BS/ISO registration? Yes ☐ No ☐

Give reasons (e.g. product quality, profitability)

6 Is the company registered to BS 7750 environmental management systems, or the ECO management and audit scheme? Yes ☐ No ☐

7 Has an environmental impact assessment been carried out on the site, or on processes or products? Yes ☐ No ☐

Comments

8. Are quality audits regularly carried out at your company? Yes ☐ No ☐

9. Are environmental audits regularly carried out in your company? Yes ☐ No ☐

10. What would your company see as the most important reasons for establishing an environmental management system? Please tick 3 of the following categories which you consider as most important.

a) Gain advantage over competitors	☐	h) Legislative compliance	☐
b) Obtaining insurance	☐	i) Public relations	☐
c) Attracting finance	☐	j) Recruit & retain best staff	☐
d) Demonstrate commitment of mgt. to env. perf.	☐	k) Reduce costs (e.g. improved waste mgt.)	☐
e) Increase knowledge of own site and activities	☐	l) Monitor & improve environmental perfor.	☐
f) Assess compliance with corporate policy	☐	m) Educate & motivate workforce	☐
g) "Green" marketing tool	☐	n) Accreditation	☐

SECTION III: WASTE MANAGEMENT

1. What are the products your company produce? _____

_____

_____

2. Number of each product produced per week? _____

_____

3. Approximately the volume of waste generated per product a week?

During the design process _____

During the Manufacturing process _____

During the assembly process _____

During the storage process _____

During the shipping process _____

4. Are your products designed in house? If not were are they designed? _____

5. Does your company have a waste management function? Yes ☐ No ☐

6. Is waste management considered of high/low profile in your company? High ☐ Low ☐

7. Are audits carried out as part of any waste management scheme? Yes ☐ No ☐

Please specify? _____

_____

_____

8. Description of waste.

Types of Waste		Disposal Methods	
Air Emission	☐	Waste Dumps	☐
Waste Water	☐	Landfilling	☐
Solid Waste	☐	Incineration	☐
Hazardous Waste	☐	Recycling	☐
Any Other	☐	Off Site	☐
Please Specify:		In Site	☐
		Waste Exchange	☐

9. Can waste, in your company, be controlled or even avoided altogether? Yes ☐ No ☐

10. Is any of it polluting the atmosphere, the rivers and water courses, the land in general? Yes ☐ No ☐

If so, do you have any licenses (please specify).....

11. Are regular meetings held to discuss waste issues? Yes ☐ No ☐

If so, how often?.....

12. Is waste disposal monitored and recorded? Yes ☐ No ☐

SECTION IV: OTHER

1. Does your company employ people with environmental expertise / training? Yes ☐ No ☐

2. If yes, please specify with qualifications _____

3. Are your employees being trained in environmental awareness/procedures? Yes ☐ No ☐

4. Have you used consultants to assist with any of the following

a) Environmental issues	Yes ☐	No ☐
b) Quality management	Yes ☐	No ☐
c) Waste management	Yes ☐	No ☐

5. Would you like a member of the university staff to visit your company with an information pack, to assess the current environmental situation, free of charge? Yes ☐ No ☐

Any other comments on the above questionnaire?

_____

_____

_____

_____

_____

Signed: ..... Date: ..../..../....

THANK YOU FOR YOUR TIME AND CO-OPERATION

(Could you please return the completed questionnaire in the freepost envelope provided by the latest date of of 1996)

APPENDIX III – CASE STUDIES

Case Study – Company A

Over the past ten years, Company A has downsized from 3000 to 300 people. More job losses are imminent making the company a SME.

Company A participated in the *Environmental Enterprise Project* for eight months. The key objective was to reduce costs through waste minimisation, but the corporate sponsor and Business Unit manager wanted to drive the creation of a new world class culture throughout the company.

The Waste Minimisation team goals included:

- Job security
- Improved profitability
- Team working
- Recognition for a job well done

The initial analysis to the culture of the company, undertaken within the project methodology, have showed that:

- Company A, although a SME company, had retained the culture, attitudes and bureaucracy of a large company
- The workforce were not aware of the company business objectives
- There was a substantial amount of waste in the Business Unit (benchmark for all company was 15% of turnover)
- There was a need for increased recognition of staff and training in the company
- Communications needed substantial improvement

In the project area, waste was tracked to a value of £318k. This was to be reduced to £100k

by the end of the year producing a saving of £218k, but beyond this further reductions were needed.

Other project results included:

- Restructuring of the pay and reward system linking quality of finished product to bonus. Previously the bonus was based upon weight of product delivered along the line
- Multi-skilling of people
- Team based culture
- Rigorous waste tracking and waste budgets to each section
- Amendments to management accounting procedures to make waste transparent
- Breaking down of barriers between sections and between management of the workforce
- Dramatic changes in working practices
- The regular use of systematic waste tracking and problem solving

Case Study Company C– Waste Minimisation Leads to the Successful Management of Change

This case study reports the benefits of using the EFQM model to analyse the current structures within a company. Company C belongs in the service sector and one of the key objectives was to bolster working partnerships between individual departments, to enable them to function more effectively. In order to achieve this objective, the company must evaluate where it is now, decide where it wants to go, and by when, and then create a route map of how to get there. Another aim of the company was to achieve ISO 9001 quality accreditation and Investors in People status since, in the current business climate, these standards are essentially *"permits to work"*. Nevertheless, it was pointed out that these standards *per se* will not assure survival in the long term unless they are used to drive the business objectives. This was achieved firstly through waste minimisation and process simplification and secondly by training people to acquire skills which are essential to the achievement of departmental business goals which support the company's overall vision.

The *Environmental Mentoring Project* has commenced this journey by facilitating staff to agree a new mission statement that would enthuse everyone. The project has also brought departmental managers to a realisation that they must work together to support the management in their goal. The project has helped to create a *"single team"* approach to the management of change with recognition of the need for departments to share resources. This made a lot easier to change the role of clerical staff. Process simplification was also achieved to eliminate waste, defined as anything that does not add value to the customer. When processes have been simplified then they can be reduced incorporated into the quality management system.

The biggest challenge facing management was to lead change whilst maintaining staff morale and maintained support for the change process. This was achieved through leadership, openness and effective communication.

The key objective when competing on quality and price is to identify and eliminate waste, to reduce overheads, and to ensure that the company obtains a reputation for this innovation.

The project approach is then essential in this respect because it provided a structured approach to measuring waste. This provided the engine for change which everyone in the company could understand and participate. It also provided a spur to innovation.

Since the company needed to manage change effectively, it was deemed essential that the change should be set in the context of the values, mission and vision of the company. The fostering of a genuine commitment rather than compliance is therefore based upon the need for a shared vision. This is essential in terms of ensuring on-going staff commitment to support structural change that might be uncomfortable in order to produce medium-term improvements. People excel and learn, not because they are told to, but because they want to. The vision alone will however not produce results. It is therefore important that the change should be set in a framework or context. The EFQM was therefore used to provide such a framework. The results scored under the model are listed in Table III.1.

Criteria Name	% = Score / Max
Leadership	46 = 46 /100
Policy & Strategy	45 = 36 / 80
People Management	34 = 31 /90
Resources	38 = 34 / 90
Processes	32 = 45 / 140
Customer Satisfaction	48 = 96 / 200
People Satisfaction	24 = 22 / 90
Impact on Society	43= 26 / 60
Business Results	40 = 60 / 150

Table III.1 - Results from Using Rapid Assess Score

Table III.2 represents what the above results actually mean for the company:

Category	Description
Leadership of change	The project has assisted with the development of the vision by facilitating staff to develop a Mission Statement. Leading change is a skill which is based upon the need to enthuse people. The objective of leadership is therefore to maintain the "family" atmosphere at the company so that the strong level of staff commitment can be used to implement the necessary changes. The leadership role is therefore to create a shared vision to which everyone is committed. The priority area for action was then the identification and promotion of shared beliefs and goals. The project also delivered the principle of internal customers and suppliers which provided a basis for future improvement of quality and value for money.
Policy & Strategy	It was identified that the company had a *"family"* atmosphere of mutual support and respect. Having created the vision the next step was to develop policies and strategies that, when deployed, will deliver the vision. The engine that drives policy and strategy formulation includes: customer requirements, benchmarking against competitors, supplier development and regulation. It is important that staff are involved in all the key areas of policy deployment and implementation that effect each of their own areas. This will improve EFQM ranking in 45%. Another priority area identified was the need for effective communication systems. The communication should be two-way by converting strategies into plans for each department and listening to ideas from customers and administration people who are responsible for the implementation of changes.
People Management	The EFQM score under this area was 34%. This was considered to be a priority area. There appeared to be a strong desired for teamworking, responsibility and involvement. This ideal for the achievement of the vision. The programme has started by ensuring that the middle management team recognised that all services were interconnected and actions within one department can have a dramatic effect on other departments. Another area identified and implemented was skills development and training.
Resources	The initial EFQM score showed that there were major opportunities to improve in this area. A key area for action was identified has being information systems, making the right information available in a simple format when it is needed. Knowledge management was the other priority action area to be identified.
Processes	This measure scored 32% in the EFQM evaluation. There is a great need for process simplification and team accountability. This is where the *Waste Minimisation* methodology started. This reduced pressure on staff time and created resources for other areas of change.

Table III.2 - Issues Raised at the Company from Project Participation

Case Study Company K – Waste Minimisation Leads to Business Growth

"For us, waste minimisation means an opportunity to be creative and to change the way we work, to improve profits and protect the environment" Manufacturing Manager, Company K.

Company K, employs 275 people in the design and manufacture of architectural aluminium systems. Company K has taken a structured approach to waste minimisation by being a participant in the *Environmental Mentoring Project.* The result of its participation on the project was a basis to develop a programme for sustained business growth. They were able to take an overview of their processes and develop a waste-tracking model from which priority areas for action were identified easily.

The benefits for the company were:

- Cost savings of £50,000/year through a reduction in spoilage, with a payback period of under three weeks
- Cost savings of £210,000/year through reduction in paint use and increased throughput, with a payback period of two years
- A people-centred approach that has created a culture of continuous improvement
- A firm basis for decision-making for future capital investment

The company started the programme, decided to look afresh at all its processes, and involve its employees at all stages. As a result of this project, employees are now fully aware of waste and its costs to the company and their performance bonus. The combination of motivated people, training, and capital investment has produced significant cost savings and the foundation for continuous improvement for growth.

For company K, like many businesses, plant yield (the ratio of material input to good material dispatched to the customer) is a significant indicator of business profitability. Improvement in yield is a critical measure for business success.

One key area for improvement identified by the company was the need to reduce waste in

materials handling. It was discovered that in the aluminium section, dents occurred which lead to losses of £70,000/year in wasted product. The main reason for this was the materials spent more time in transit through the plant that being processed. The measurement of this waste allowed for improvement targets to be set. People-centred issues were handled first, with waste minimisation awareness workshops being held for all shop floor employees. The result was the establishment of new working procedures which included:

- Cooling the material before movement
- Increasing the number of material supports and buffers for transportation
- Reduced material handling
- Revised standard operation procedures

Taking a structured approach to process improvement through Waste Minimisation has pinpointed where capital investment can improve yield and product throughput. A new closed paint booth has saved an additional £21,0000/year through reduction in powder paint consumption. This has been achieved because of the controlled environment and material recovery/re-use system, and has enabled production capacity to increase to meet strong product demand. This was achieved through a capital spend of £420,000 with a two-year payback period.

Case Study Company Y– Waste Minimisation Leads to Easy Cost Savings

"Our membership of the Waste Minimisation Programme have enabled us to take the first steps towards a continuous improvement culture to constantly reduce waste and improve our environmental performance" Health, Safety and Environmental Manager, Company Y

Company Y employs 119 people in the manufacture of chemicals for genetic analysis and life science markets. This project helped the company to take a bird's-eye view of its processes and develop a waste-tracking model from which priority areas for action were identified.

The use of worksheets ensured that the effort was spent on the areas that would deliver the greatest financial savings in the shortest time.

The cost savings and environmental benefits that resulted included:

- Savings of £44,000 in the first year with total potential savings of £220,000/year
- Payback on investment within 5 weeks
- Reduced exposure of staff to chemicals
- Reduced hazardous waste disposal costs

Company's Y main objective in using the waste minimisation methodology was to reduce costs as well as to improve environmental performance. The Health, Safety and Environmental Manager used the Opportunity Checklist and the Flowsheet model to take an overview of their business. The picture gained from this approach allowed her to review inputs and outputs at each stage of the manufacturing process. It was then easy to use the worksheets to identify opportunities for saving money by measuring waste at each stage.

Although the business had grown, raw materials were still delivered in the same range of small-sized containers. The empty containers were disposed of to landfill at a cost of £12 each. A process re-design permitted the use of bulk 200-litre chemical drums. The chemical supplier now collects and refills the re-usable stainless steel drums. This simple measure has brought many benefits.

- Elimination of hazardous waste disposal costs;
- No need to store a large number of small containers;
- Use of fewer containers means there is less residue and thus less raw material waste;
- Reduction in manual handling of employees to chemicals and a reduction in the need for quality control testing; and
- Investment in re-usable stainless steel drums has brought a saving in packaging materials and also reduced the company's obligation under the packaging waste regulations.

The total investment of £3,000 in re-usable stainless steel drums was recovered within 5 weeks. The success of the approach has led to an internal waste-watching team being established, which has identified additional waste-saving opportunities totalling £220,000.

LIST OF REFERENCES

Aly, M. (1997). Is Self-Assessment (as a powerful tool for total quality management implementation) Suitable in The Middle East Context? The Experience of a Petrochemical Global Company. *Total Quality Management*, 8(2 & 3), pp. 54-59.

Anon. (1993). *1993 Towards Sustainability. A European Programme of Policy and Action in Relation to the Environment and Sustainable Development.* Official Journal of the European Communities C138, 17 May pp. 5-98.

Anon. (1995). *Leicestershire Waste Minimisation Initiative – Project Report.* Leicestershire County Council, March, Paper Flow Services. Birmingham.

Anon. (1996). *Attitudes and Barriers to Improved Environmental Performance: Cross – Sectorial Analysis.* Environmental Best Practice Programme (ET57).

Anon. (1996). *Commission Recommendation of 3rd April 1996 Concerning the Definition of Small and Medium Enterprises.* Official Journal of the European Communities (96/280/EC).

Anon. (1996). *GG38 Cutting Costs by Reducing Waste A self help guide for growing businesses.* Environmental Technology Best Practice Programme.

Anon. (1997). *A Green and Competitive Edge for the North West, Promoting Environmental Best Practice in Business and Industry – Draft Paper for Consultation.* National Centre for Business & Ecology, University of Salford. Manchester.

Anthony, S. and Holt, D. (1999). *Exploring "Green" Culture in Nortel and Middlesex University.* Proceedings from the Symposium on Culture, Organisations and the Environment, 2nd July, University of Leeds, UK, pp. 10-14.

Ballard, D. (1997). *Leadership and the Environmental Crisis,* Bath Consultancy Group Working Paper.

Ballard, D. (1999). *Change for Sustainable Development – Addressing the Cultural Dimension.* Proceedings from the Symposium on Culture, Organisations and the Environment, 2nd July, University of Leeds, UK, pp. 39-48.

Baylis, R. Connell, L. and Flynn, A. (1997). *Environmental Regulation and Management: A Preliminary Analysis of a Survey of Manufacturing and Processing Companies in South Wales.* Papers in Environmental Planning Research, **11**.

BCC (1994). *Small Firms Survey – Environment and the View of the Small Firm.* The Association of British Chambers of Commerce, London.

Bennett, L. and Kerr, M. (1996). A systems Approach to The Implementation of Total Quality Management. *Total Quality Management*, **7**(6), pp. 631-665.

Bicheno, J. (1991). *34 for Quality – A Guide to Gurus, Tools, Wastes and Techniques.* PICSIE Books, England.

Bicheno, J. (1998). *The Lean Toolbox - A Quick and Dirty Guide for Cost, Quality, Delivery, Design and Management.* PICSIE Books, England.

Bicheno, J. (1998). *The Quality 60.* PICSIE Books, England.

Biffa Waste Services (1994). *Waste A Game of Snakes and Ladders?* High Wycombe.

Black, S. and Crumley, H. (1997). Self-Assessment: What's in it for us? *Total Quality Management*, **8** (2 & 3), pp. 90-93.

Bolton, J.E. (1971). *Report of the Committee of Inquiry on Small Firms.* Cmnd 4811, HMSO, London.

Boustead, I. (1992). *The relevance of re-use and recycling activities for the LCA profile of products.* Proceedings 3rd CESIO International Surfancts Congress and Exhibition. London pp. 218-226.

British Chambers of Commerce (1994). *Small Business Survey – Environment.* Association of British Chambers of Commerce, London.

British Quality Foundation (1997). *Guide to Self-Assessment.* British Quality Foundation, London.

Brown, A. (1998). *Organisational Culture.* Pitman Publishing (Second Edition), London.

Brown, S. (1996). *Strategic Manufacturing for Competitive Advantage – Transforming Operations from Shop Floor to Strategy.* Prentice Hall, London.

Chatman, J. and Jehn, K. (1994). Assessing The Relationship Between Industry Characteristics And Organisational Culture: How Different Can You Be? *Academy of Management Journal,* **37**(3), pp. 522-553.

Clark, R.M. (1978). *Analysis of Urban Solid Waste Services - A Systems Approach.* Ann Arbor Science Publishers.

Coggins, P. (1993). *The Important Option of Waste Minimisation.* Waste Management Proceedings, April, pp.9-12.

Cohen, W. and Levinthal, D. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, **35**, pp. 128-152.

Cole, R. (1998). Learning from the Quality Movement: What did and didn't happen and why? *California Management Review*, **41**(1).

Connel, L., Baylis, R. and Flynn, A. (1998). *Mapping the Maze – A Directory of Essential Environmental Legislation for Small Business Managers in Wales and England.* Cardiff University. Cardiff University Press.

Connella, P.A. and Rittmeyer, R.W. (1990). *Waste Minimisation/Pollution Prevention*, Pollution Engineering.

Conti, T. (1997). Optimising Self-Assessment. *Total Quality Management*, **8** (2 & 3), 5-15.

Cooper, T. (1994). *Beyond Recycling: The Longer Life Option.* New Economics Foundation.

Coopers & Lybrand, (1995). *EC Eco-Management and Audit Scheme (EMAS) – Positioning your Business,* Business in the Environment, London.

Cramer, J. (1998). Environmental Management From "Fit" to "Stretch". *Business Strategy & The Environment* **7**.

Crittenden, B. and Kolaczkowski, S. (1995). *Waste Minimisation a Practical Guide.* Institution of Chemical Engineers, Rugby.

Croner's Waste Management (1991). Croner Publications Ltd, Kingston upon Thames.

Crosby, P. (1979). *Quality is Free: The Art of Making Quality Certain.* McGraw Hill, New York (USA).

Crosby, P. (1989). *Let's Talk Quality.* McGraw Hill, New York (USA).

Curran, J. and Blackburn, R. (1994). *Small Firms and Local Economic Networks: The Death of The Local Economy.* Chapman, London.

Cusumano (1985). *The Japanese Automobile Industry: Technology and management at Nissan and Toyota.* Harvard Business Press, Cambridge.

Daly, M. and McCann, A. (1992). "How Many Small Firms?" *Employment Gazette*, February, pp. 47-51.

Deming, W. E. (1986). *Out of the Crisis: Quality, Productivity and Competitive Position.* Cambridge University Press, Cambridge.

Department of Trade and Industry (1994). *Report on the DEMOS Project Event.* Manchester Airport, 27th June.

DNV Quality Assurance Limited (1996). *Environmental Management Systems – BS 7750, EMAS and ISO14001 – An Independent Guide.* DNV Quality Assurance Limited.

DoE (1992). *Digest of Environmental Protection and Waste Statistics.* Department of the Environment. HMSO, London, **15**.

DoE (1994). *Sustainable Development – The UK Strategy Summary Report.* Department of the Environment, HMSO, London.

DoE and the Welsh Office (1995). *A Waste Strategy for England and Wales, consultation draft.* HSMO, London.

Drummond, H. (1995). Beyond Quality. *Journal of General Management*, **20**(4), pp. 68-77.

DTI (1992). *Small Firms in Britain Reports.* Department of Trade and Industry, HMSO, London.

DTI (1994). *Small Firms in Britain Reports.* Department of Trade and Industry, HMSO, London.

DTI (1995). *Small Firms in Britain Reports.* Department of Trade and Industry, HMSO, London.

Eden, S. (1996). *Environmental Issues & Business, Implications of a Changing Agenda.* John Wiley & Sons.

Eduljee, G.H. and Arthur, D.A., (1995). *Solid Waste Management* published in Pollution Causes, effects and control" 3rd Edition. Edited by Roy Harrison, The Royal Society of Chemistry.

Elkington, J. (1994). Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development. *California Management Review*, Winter, pp. 90-100.

Elkington, J. and Fennel, J. (1998). *Can Business Leaders Satisfy the Triple Bottom Line?* Management, London, UK, pp. 34-36.

Elkington, J. and Hailes, J. (1988). *The Green Consumer Guide.* Victor Gollanez.

Everard, M. (2000). Aquatic Ecology, Economy and Society: The Place of Aquatic Ecology in the Sustainability Agenda. *Freshwater Forum*, **13**, pp. 31-46.

Feigenbaum, A. (1956). Total Quality Control. *Harvard Business Review*, **34**(6), pp. 93-101.

Feigenbaum, A. (1991). *Total Quality Control*, Third Edition, McGraw Hill.

Flood, R. (1993). *Beyond TQM.* Chichester, Wiley.

Florida, R. (1996). Lean and Green: The Move to Environmentally Conscious Manufacturing. *California Management Review*, **39**(1), pp. 80-105.

Flower *et al* (1992). *A New Graphical Method for Choosing Better Mass Flowsheets for Environmental Aware Processes.* Proceedings Conference on Effluent Treatment and Waste Minimisation, Institute of Chemical Engineers.

Freire, A. (1997). *Estratégia – Sucesso em Portugal.* Editorial Verbo, Lisboa.

Gascoigne, J.L. and Olgivie, S.M. (1995). *Recycling Waste Materials: Opportunities and Barriers.* Issues in Environmental Science Technology **3,** Waste Treatment and Disposal. Editors Hester and Harrison.

Ghoshal, S. and Barlett, A. (1987). *The Individualised Corporation: A Fundamentally New Approach to Management.* HarpperCollins Publishers, New York (USA).

Gladwin, T., Kennelly, J. and Krause, T. (1995). Shifting Paradigms for Sustainable Development: Implications for Management Theory And Research. *Academy of Management Review*, **20**(4), pp. 874-907.

Greenberg, M., Carvana, J. and Krugman, B. (1976). Solid Waste Management: a test of alternative strategies using optimisation techniques. *Environmental Planning*, **8**, pp. 587-597.

Groundwork (1995). *Small Firms and the Environment.* A Groundwork Status Report. Groundwork National Office.

Harrington, H. (1991). *Business Improvement.* McGraw Hill, New York (USA).

Hartman, C. and Stafford, E. (1998). Crafting "Entrepreneurial" Value Chain Strategies Through Green Alliances. *Business Horizons*, March-April, **41**(2), pp. 62-72.

Henriques, I. and Sadorsky, P. (1999). The Relationship Between Environmental Commitment And Managerial Perceptions Of Stakeholder Importance. *Academy of Management Journal*, **42**(1), pp. 87-99.

Hindle, P., White, P.R. and Ninion, K. (1993). Achieving real environmental improvement using value impact assessment. *Long Range Planning*, **26**(3), pp. 36-48.

Hodgets (1996). *Implementing TQM in Small & Medium Sized Organisations*, New York (USA).

Hopper, J.R. and Yaws, C.L. (1993). *Waste Minimisation by Process Modification.* Waste Management, **13**, pp. 3-14.

Howard, R. (1990). Can Small Business Help Countries Compete? *Harvard Business Review*, November – December.

Hubber, G. (1991). *Organisational Learning: The Contributing Processes And The Literatures.* Organisation Science, **2**(1), pp. 88-115.

Hunt, C. and Auster, E. (1990). Proactive Environmental Management: Avoiding the Toxic Trap. *Sloan Management Review*, **31**(2), pp. 7-18.

Hunter, J. (1987). *Minimising waste by source segregation and inventory control.* Technical strategies for hazardous waste prevention and control seminar. Government Institutes, Inc. Washington (USA).

Hutchinson, A. and Hutchinson, F. (1995). Sustainable Regeneration of the UK's Small and Medium-Sized Enterprise Sector: Some Implications of SME Response to BS 7750. *Greener Management International*, **9**, pp. 73-84.

Interface (1997). *Sustainability Report.* Interface Inc., Atlanta (USA).

Ishikawa, K. (1990). *Introduction to Quality Control,* JUSE Press, Tokio.

IWM Waste Minimisation Working Group (1995). *Waste Minimisation.* Institute of Waste Management Publications.

Johnson, F. (1994). *Environment the View of the Small Firm – Small Firms Survey.* British Chambers of Commerce, London.

Johnston, N. (1995). *Waste Minimisation: a route to profit and cleaner production.* Final report on the Aire and Calder project, Center for Exploitation of Science and Technology, London.

Johnston, N. and Stokes, A. (1995). *Waste Minimisation and Cleaner Technology: an assessment of motivation.* Center for Exploitation of Science and Technology, London.

Jones, C. (1994). Improving your Key Business Processes. *The Total Quality Management Magazine*, **6**, pp. 25-29.

Jonker, J. (1998). The Need for a New Quality Instinct. *European Quality*, **5**(3), pp. 8-11.

Jonker, J. and Klaver, J. (1998). Integration: A Methodological Perspective on Integration. *Quality World*, **24**(8), pp. 22-23.

Jonker, J. and Klaver, J. (1998). *The Significance of Recent SEM Standards as an Impetus for Improvement.* Eco-Management and Auditing Conference, Sheffield (UK), pp. 1-35.

Jonker, J. and Klaver, J. (1999). *Environmental Management: Patterns of Change and Implementation.* Proceedings from the Symposium on Culture, Organisations and the Environment, 2nd July, University of Leeds, UK, pp. 32-38.

Jonker, J. and Klaver, J. (1999). *Sustainability as a Way of Being: Changing from Instrumentalism Towards Attitude.* Proceedings from the Symposium on Culture, Organisations and the Environment, 2nd July, University of Leeds, UK, pp. 1-10.

Juran, J. (1988). *Juran on Planning for Quality.* The Free Press.

Juran, J. and Gryna, F. (1988). *Juran's Quality Control Handbook.* McGraw Hill (4th Edition), New York (USA).

Kanji, G. (1996). Can Total Quality Management Help Innovation? *Total Quality Management*, **7**(1), pp. 3-9.

Kanji, Yui (1997). Total Quality Culture. *Total Quality Management*, **8**(6), pp. 417-428.

Kirkland, L. (1997). *Introducing Environmental Management Systems to Corporation.* Masters Degree, Faculty of Environmental Design, the University of Calgary.

Kirkland, L. and Thompson, D. (1999). Challenges in Designing, Implementing and Operating an Environmental Management System. *Business Strategy and The Environment*, **8**.

Klaver, J. and Jonker, J. (1998). The Significance of Recent EMS Standards As An Impetus For Improvement. *Eco-Management and Auditing*, **5**, pp. 1-5.

Kok, E. and Saintbris, H. (1994). Voluntary Environmental Initiatives in Industry: What Role for EMS? *European Environment*, **4**, August, pp.14-17.

KPMG (1994). *UK Environmental Reporting Survey.* KPMG, London.

KPMG (1997). *The Environmental Challenge and Small and Medium Sized Enterprises in Europe.* KPMG Consulting, The Hague.

Lewis, K. Lytton, S. (1997). *How to Transform your Company and Enjoy it.* Management Books 2000. Cowcombe Hill, Gloucestershire.

Lloyd, S. and Oliveira, E. (1999). *Waste Minimisation – A Way Forward for Sustainable Development in the SME Sector.* Sustainable Use of Natural Resources – Cooperative Planning and Action, Environmental Training Engineering Education (ENTRÉE), Tampere, Finland, pp. 79-87.

Loffer, P. (1998). Sustainable Development in Europe: A Case for Regional Innovation Strategies. *European Environment*, **8**, pp. 113-120.

Longbottom, D. (1997). Self-Assessment: The 300-point Barrier. *Total Quality Management*, **8**(2 & 3), pp. 211-216.

Malandrini, A. (1999). *Culture, Organisation and the Environment: The Eco-Preneuring Logic.* Proceedings from the Symposium on Culture, Organisations and the Environment, 2nd July, University of Leeds, UK, pp. 68-76.

March Consulting Group, (1994). *Project Catalyst, Report on the Demos Project Event*, Aspects International, Manchester Airport, Wigan.

Merritt, J.Q. (1998). EM Into SME Won't Go? Attitudes, Awareness and Practices in The London Borough of Croydon. *Business Strategy & The Environment*, **7**.

Monden, Y (1981a). What Makes the Toyota Production System really Tick? *Industrial Engineering*, January, pp. 36-46.

Monden, Y (1981b). Adaptable Kanban System Helps Toyota Maintain Just-in-Time Production. *Industrial Engineering*, May, pp. 28-46.

Monden, Y (1981c). Smoothed Production Lets Toyota Adapt to Demand Changes and Reduce Inventory. *Industrial Engineering*, August, pp. 41-51.

Monden, Y (1981d). How Toyota Shortened Supply Lot Production Time, Waiting Time and Conveyance Time. *Industrial Engineering*, September, pp. 22-30.

Monden, Y (1985). *Applying Just-in-Time: The American/Japanese Experience.* Industrial Engineering and Management Press, Norcross.

Monden, Y (1993). *Toyota Production System: an Integrated Approach to Just-In-Time.* Industrial Engineering and Management Press (Second Edition).

Morgan, B. (1997). *Small & Medium Enterprises and Economic Development.* Welsh Economic Review, Welsh Development Agency.

MSI Data Report: (1995). *Waste Management UK*

O'Laoire, D. and Welford, R. (1995). The Environmental Management System In Small & Medium-Sized Enterprises Using ISO 14000. *Eco-Management and Auditing*, **2**, pp. 12-17.

Oakland, J. (1993). *Total Quality Management.* Butterworth-Heineman, (2nd Edition), Oxford.

Ohno, T. (1985). *Japan Management Association, Kanban: Just-In-Time at Toyota.* Productivity Press.

Oliveira, E.R. and Lloyd, S. (1997). *Environmental Legislation - Its Impact On Product Design* paper presented at the Product Design Conference held at the University of Glamorgan.

Oliveira, E.R. and Lloyd, S. (1999). *Improving Process Efficiency Through Waste Minimisation – The Development of a Methodology.* Proceedings from the Symposium on Culture, Organisations and the Environment, 2nd July, University of Leeds, UK, pp. 77-86.

Orr & Boss (1991). *Towards Zero Waste: 101 Waste-Busting Tips.* Alderley Edge.

Palmer, J. and Van Der Vorst, R. (1996). Are "Standard" Systems Right for SMEs? *Eco-Management and Auditing*, **3**, pp. 91-96.

Patton, D. and Baron, P. (1995). Factors Influencing Companies' Response to Environmental Responsibility. *Eco-Management and Auditing*, **12**, pp. 41-46.

Pearce, D.W. and Turner, R.K. (1992). *Packaging Waste and the Polluter Pays Principle - a taxation solution working paper.* Centre for Social and Economic Research on the Global Environment.

Pearson, B., Little, B.F.P. and Brierley, M.J. (1992). *Using environmental management systems to improve profits.* Kluwer Law International, London.

Petts J., Herd A. and O'Heocha (1998). Environmental Responsiveness, Individuals and Organisational Learning: SME Experience. *Journal of Environmental Planning and Management*, **41**(6), pp. 711-730.

Petts, J., Herd, A., Gerrard, S. and Horne, C. (1999). *Business Attitudes to Environmental Compliance: Perceptions within Small & Medium Sized Enterprises (SMEs).* Global Environmental Change Programme Briefings. Number 25, March. Published by the Programme Office.

Petts, J., Herd, A., Gerrard, S. and Horne, C. (1999). The Climate and Culture of Environmental Compliance within SMEs. *Business Strategy and the Environment*, **8**, pp. 14-30.

Pilkington, A. (1998). Manufacturing Strategy Regained: Evidence for the Demise of Best-Practice. *California Management Review*, **41**(1).

Porter, M. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance.* The Free Press, New York.

Porter, M. and Van der Linde, C. (1995). Green & Competitive: Ending the Stalemate. *Harvard Business Review*, **73**(5), pp. 120-134.

Post, J. and Altman, B. (1994). Managing The Environmental Change Process: Barriers And Opportunities. *Journal of Organisational Change Management*, 7(4), pp. 64-81.

Potter and Isalski (1992). HAZOP for the Environment. *The Chemical Engineer*, **529**, Environmental Supplement, pp. 27-28.

Price, B. (1996). *Waste Minimisation A cross industry review of current practices and trends*; Financial Times Management Reports.

Riat, A. (1996). *"Best Practice" Lean Production in Small to Medium Sized Manufacturing Enterprises and its Assessment.* PhD Thesis, University of Sunderland.

Roome, N. (1992). Developing environmental management strategies. *Business Strategy & the Environment.* **1**, pp. 11-24.

Rosenbaum, W. (1997). *Legal Issues for Small to Medium Enterprises.* Paper presented at the American Society for Quality Control and Environmental Standards Integration Conference, San Diego (USA).

Rowe, J. and Hollingsworth, D. (1996). Improving the Environmental Performance of Small and Medium Sized Enterprises: A Study in Avon. *Eco-Management and Auditing*, **3**, pp. 97-107.

Royal Society of Chemistry (1996). *Simple Guide on Management and Control of Wastes*, London.

SABINA (1998). *Severn Estuary Waste Minimisation Project.* The Welsh Office Sustainable Business in Action, WSP Environmental.

Schaefer, A. and Harvey, B. (1999). *Environmental Knowledge and the Adoption of Ready Made Environmental Management Solutions.* Proceedings from the Symposium on Culture, Organisations and the Environment, 2nd July, University of Leeds, UK, pp. 58-67.

SERC (1994). *Stopping Waste within the Production Process.* Clean Technology Unit.

Shingo, S. (1981). *Study of Toyota Production System from Industrial Engineering Viewpoint.* Japan Management Association, Tokio.

Shingo, S. (1986). *Zero Quality Control: Source Inspection and the Poka-yoke System.* Cambridge Productivity Press, Cambridge.

Shingo, S. (1992). *The Shingo Production Management System: Improving Process Functions.* Cambridge Productivity Press, Cambridge.

Shrivastava, P. and Hart, S. (1995). Creating Sustainable Organisations. *Business Strategy and the Environment*, **4**, pp. 154-165.

Spencer, B. (1994). Models of Organisation And Total Quality Management: A Comparison And Critical Evaluation. *Academy of Management Review*, **19**(3), pp. 446-471.

Stanworth *et al* (1991). *Bolton 20 Years On: The Small Firm in the 1990s.* SBRT, London.

Storey (1994). *Understanding the Small Business Sector.* Routledge, London and New York.

Sushil (1990). Waste Management: A Systems Perspective. *Industrial Management and Data Systems*, **90**(5), pp. 7-66.

Touche Ross (1990). *Head in the Clouds or Head in the Sand? UK Managers Attitudes to Environmental Issues.* Touche Ross, London.

TQM International (1995). *Total Quality Management - Using Quality Tools and Techniques Successfully – Discussion Book.* TQM International Ltd.

US EPA (1988). *Waste Minimisation Opportunity Assessment Manual*, Cincinnati.

Walsh, P. (1996). Finding Key Performance Drivers: Some New Tools. *Total Quality Management*, **7**(5), pp. 509-519.

Watkins, M. (1999). *Understanding Stakeholders.* Proceedings from the 1999 Eco-Management and Auditing Conference, 1/2nd July, ERP Environment, University of Leeds, UK, pp. 355-364.

WCED (1987). *Our Common Future* - World Commission on Environment and Development, Oxford University Press, Oxford, England.

Welford, R (1996). *Corporate Environmental Management: Systems and Strategies.* Earthscan, London.

Welford, R. (1997). *Corporate Environmental Management 2: Culture and Organisations.* Earthscan, London.

Wilson, G. and Corry, E. (1997). Continuous Improvement at Coca-Cola Bottlers (Ulster) Ltd: The development of a self-assessment methodology. *Total Quality Management*, **8**(1), pp. 83-89.

Winter, L. and Ledgerwood, G. (1994). Motivation and Compliance in Environmental Performance for Small and Medium-Sized Businesses: A Model Based on Empirical Evidence from a Pilot Investigation of Small Businesses in the English West Midlands. *Greener Management International*, **7**, pp. 62-72.

Wisner, J. D. and Eakins, S.G. (1994). A Competitive Assessment of the Baldrige Winners. *Total Quality Review*, **4**, pp. 15.

Wolf, R. (1998). Beyond Environmental Management: Perspectives on Environmental and Management Research. *Business Strategy and the Environment*, **7**, pp. 297-308.

Womack, J. and Jones, D. (1996). Beyond Toyota: How to Root Out Waste and Pursue Perfection. *Harvard Business Review*, September – October.

Womack, J. and Jones, D. (1996). *Lean Thinking - Banish Waste And Create Wealth in Your Corporation.* Simon & Schuster, New York (USA).

Womack, J., Jones, D. and Roos, D. (1990). *The Machine That Changed the World,* Macmillan, London.

Wubben, E. (1999). What's in it for us? Or: The Impact of Environmental Legislation on Competitiveness. *Business Strategy and the Environment,* **8**.

WWF (1998). *Living Planet Index.* Worldwide Fund for Nature, Godalmining.

Zairi, M. (1994). *Measuring Performance for Business Results.* London, Chapman & Hall.

Zelfane *et al,* (1995). Corporate Environmental Commitment: Developing the Operational Concept. *Business Strategy and the Environment*, **3**(4), pp. 17-28.