Developing Sustainable Products and Services in Industry

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ABSTRACT

The problem that this research aims to contribute a solution towards is that products at all stages of their lifecycle (from raw materials, production, consumption to end of life) can cause adverse environmental and social impacts. In a Triple Bottom Line (TBL) context these can be referred to as adverse sustainability impacts. The resultant environmental impacts can be so significant that products and their consumption are seen as a major contributor to environmental degradation. The adverse social impacts are increasingly prominent in line with globalisation and the growing trend towards sub-contract supply chains in the developing world. This is a significant problem whose solution, under the umbrella term of Sustainable Consumption and Production, has many facets and impacts upon many stakeholders. One element of the solution is the development of more sustainable offerings (whether they be products and/or services), which is the focus of this research project.

This research identified and assessed existing available approaches, supports, industry practices, drivers and requirements in this area. At present, a range of approaches have been developed for reducing the environmental impacts of products. Supports aimed at developing TBL sustainable offerings, to incorporate not just environmental impacts but also social and economic impacts, are in their infancy. In this research, a new TBL focused Sustainable Product and Service Development (SPSD) approach for use by industry was developed and tested in industry. This SPSD approach evolves the existing approaches to provide industry with a support for developing TBL sustainable offerings. The research also reveals the role for this approach and the wider issues and stakeholder engagement relevant to moving towards Sustainable Consumption and Production.

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ABBREVIATIONS / ACRONYNMS

B2B	Business to Business
CE	Concurrent Engineering
DfE	Design for Environment
EAPD	Environmental Adapted Product Development
EC	European Commission
ECDM	Environmentally Conscious Design and Manufacture
ECP	Environmentally Conscious Products
EEE	Electrical and Electronic Equipment
EMS	Environmental Management System
ELV	End of Life Vehicles
EPD	Environmental Product Development
ESP	Environmentally Superior Products
EPR	Extended Producer Responsibility
EU	European Union
EuP	Energy Using Products
GDP	Gross Domestic Product
GNP	Gross National Product
GRI	Global Reporting Initiative
ICT	Information Communications Technology
IPDM	Integrated Product Development Methodology
IPP	Integrated Product Policy
IPPC	Integrated Pollution Prevention Control
ISO	International Standards Organisation
LCA	Life Cycle Assessment
LCD	Life Cycle Design
LCI	Life Cycle Inventory
MNC	Multinational Corporations
MSPD	Method of Sustainable Product Development
NGO	Non Governmental Organisation
OECD	Organisation of Economic Co-operation and Development
OEM	Original Equipment Manufacturer
POEMS	Product Orientated Environmental Management Systems
PSS	Product Service System
RoHS	Restriction of Hazardous Substances
SC	Supply Chain
SCD	Supply Chain Dynamics
SCM	Supply Chain Management
SCP	Sustainable Consumption and Production
SD	Sustainable Development
SMEs	Small and Medium Sized Enterprises
SPD	Sustainable Product Development
SPDD	Sustainable Product Development & Design
SPSD	Sustainable Product and Service Development
TBL	Triple Bottom Line
TCO	Total Cost of Ownership

ABBREVIATIONS / ACRONYNMS

TNS	The Natural Step
UNEP	United Nations Environment Programme
UNEP-WG-SPD	United Nations Environment Programme Working Group on Sustainable Product Development
WBCSD	World Business Council for Sustainable Development
WEEE	Waste from Electrical and Electronic Equipment

"There is a tension at the heart of modern consumer societies. We want all the things the modern economy offers in terms of variety of products and services available to improve our quality of life, but we do not want the downsides such as pollution, congestion, waste or adverse impacts related to health or crime." (Changing Patterns - UK Government Framework for Sustainable Consumption and Production (DEFRA, 2003, p. 5)

CHAPTER 1 : INTRODUCTION

1.1 INTRODUCTION

What are we doing? We excessively produce and consume to improve our quality of life, but ironically, this may be eroding that which we are striving for. This is creating a conflict and the human species is facing a crossroads. Recognising this and the adverse environmental and social impacts that can be associated with production and consumption was one of the reasons for conducting this research project. The research aims to contribute a solution towards the problem that products at all stages of their lifecycle (from raw materials, production, consumption to end of life) can cause adverse environmental and social impacts. In a Triple Bottom Line (TBL) sustainability context[1] these can be referred to as adverse sustainability impacts. The resulting environmental impacts are so significant that products and their consumption are seen as a major contributor to environmental degradation (UNEP I&E, 1997; EC, 1998; EC, 2000; EC, 2001, UNDESA, 2002; EC, 2003; DEFRA, 2003; WWI, 2004). Also, the adverse social impacts are increasingly prominent in line with globalisation and the growing trend towards sub-contract supply chains in the developing world (Elkington, 1997; Charter and Tischner, 2001; UNDESA, 2002; Klein, 2001; WWI, 2004).

This is a significant problem whose solution has many facets with impacts on many stakeholders. Elements of the solution include changing consumer behaviour, changing consumption and production patterns, creation of markets for more sustainable products

[1] TBL provides a translation of Sustainable Development into a business context focusing on environment, social and economic issues as a Triple Bottom Line as distinct from the solely economic bottom line (Elkington, 1997). This is discussed further in **Chapter 4**.

and services, as well as the design and development of sustainable offerings to meet human needs (whether they be services, products or combinations called Product Service Systems (PSS)). It is the latter element, the design and development of sustainable offerings that this research project focuses on.

At present, a range of concepts, approaches, methods and support tools have been developed to reduce the environmental impacts of products (Simon et al, 1998). Supports aimed at reducing the more holistic adverse sustainability impacts, to incorporate not just environmental impacts but also social and economic impacts, are only starting to develop (Byggeth & Broman, 2000; Holmberg et al, 2000; Charter and Tischner, 2001; Simonsson and Barthel, 2002). Due to increasing policy, legal and market drivers for manufacturing industry to incorporate sustainability criteria in their activities, there is an increasing (albeit slow) requirement for supports in this area (UNDESA, 2003). This is a significant culture change for traditional manufacturing sectors. To date the incorporation of sustainability criteria has been slow and focused mainly on reducing the environmental impacts of products at specific lifecycle stages e.g. raw materials, production or end of life (European Foundation, 1997; Fava and Saur, 2002) as distinct from focusing on TBL sustainability incorporating environmental, social and economic issues. **This research reviewed and assessed the existing available approaches in line with industry requirements and, developed and tested a TBL focused approach for industry to support the development of sustainable offerings.** It focused on the development of sustainable "offerings" and is a rethink of traditional product development, shifting the focus from developing more sustainable "products" to considering all options for providing an offering (whether products, services or PSS) with the aim of determining opportunities for TBL sustainability benefits.

In this chapter the research **Problem Statement** is summarised in section **1.2**. The **Research Aim and Objectives** are described in **1.3**, **Research Deliverables** in **1.4** and the **Importance, Originality and Contributions to Knowledge** in **1.5**. The overall thesis structure is outlined in **1.6**.

1.2 PROBLEM STATEMENT

The research problem is summarised by first focusing on the "big picture" problem (section **1.2.1**), then the potential solutions advocated for this problem (section **1.2.2**) and finally, focusing on the "specific" research problem (section **1.2.3**).

1.2.1 Big Picture Problem Statement

In terms of the "big picture", the research problem is that products and their consumption can cause significant adverse environmental and social impacts (EC, 1998; EC, 2000; EC, 2001; UNEP I& E et al, 1997a; UNEP WG SPD, 2000; UNDESA, 2002; EC, 2003; DEFRA, 2003; WWI, 2004). At an international level, the 2002 World Summit on Sustainable Development, highlighted current patterns of consumption and production as unsustainable with resulting adverse environmental and social impacts (UNDESA, 2002). The adverse environmental impacts of products are well known and include the extraction and use of non-renewable materials, pollutant emissions to air and water, generation of waste, and energy consumption (EC, 2003; Davidsson, 2002). These impacts are exacerbated by high population levels and, particularly in the developed world, by high product consumption rates due to high consumer demand, technological development and quickly changing consumer preferences (WWI, 2004). Classic examples include cars and electronic goods. On average, in the developed world, we change our car for a new model every three years and our mobile phone or computer every one to two years (EC, 2000). The environmental impact of such products and their consumption is an increase in the use of raw materials, energy consumption, emissions and in particular, waste generation and disposal issues. Electronic waste alone is one of the fastest growing waste streams in the EU – growing three times as fast as average municipal waste – which is resulting in an already significant sized EU electronics waste mountain (EC, 2000). It is for these reasons that products and their consumption are seen as a major contributor to environmental degradation.

Globalisation and increasing trends for sub-contract supply chains in the developing world are highlighting the adverse social impacts which can be associated with products (Charter and Tischner, 2001; UNDESA, 2002; WWI, 2004). Examples of adverse ethical & social issues include child labour, inequitable distribution of resources and inequitable trading policies (Klein, 2001; Charter and Tischner, 2001). Incidents of child labour at *Nike* and *Gap* sub-contractors in Asia are just some examples of the adverse social issues which can be associated with current product manufacturing approaches (Muck, 1998; Nike, 1999 and 2001).

In summary, products at many stages of their lifecycle can cause adverse sustainability impacts. At our present population and product consumption levels, it is already clear that the environment cannot sustain these adverse sustainability impacts (Aloisi de Larderel, 2001; UNDESA, 2002).

1.2.2 Potential Solutions

One obvious way to solve the sustainability problems associated with products is to stop producing them! However, there is a valid requirement for the functions that many of today's products provide, some of which improve quality of life. For example, where would medical diagnosis be without medical scanning and diagnostic equipment or information access and data analysis without computers? Assuming that there is a valid requirement for a function, one way to tackle the adverse sustainability impacts of products is to develop products and/or services which are more sustainable to begin with. This requires the re-evaluation of current product development in manufacturing industry to make the resulting offerings more sustainable. **Sustainable Product Development (SPD)** is the current umbrella concept for developing more sustainable products. This research investigates and develops this further.

Before focusing on this specific issue, it is important to note that the sustainability impact of products and their consumption is a diverse problem that requires an integrated solution. This not only incorporates SPD for those manufacturing products, but also includes issues

such as changing consumer behaviour and consumption patterns, the creation of markets for sustainable products and/or services, technological innovations and new business models to contribute towards reversing unsustainable trends (Davidson, 2002; Ryder, 2004, Brezet, 2004; DEFRA, 2003; UNDESA, 2002). At the big picture level, international policies and programmes are starting to accelerate a shift towards Sustainable Consumption and Production (SCP) (UNDESA, 2002; DEFRA, 2003; EC, 2003e). Some specialists propose the holistic concept of "Sustainable Solutions" as the way forward (Stahel, 2001; Charter and Tischner, 2001). The Charter and Tischner definition for Sustainable Solutions is:-

> *"products, services, hybrids or system changes that minimise negative and maximise positive sustainability impacts – economic, environmental, social and ethical – throughout and beyond the life-cycle of existing products or solutions, while fulfilling acceptable societal demands/needs. Sustainable Solutions require multi-stakeholder engagement and involve changes or shifts in consumption and production patterns. The aim of sustainable solutions is to create a positive net sustainable value (positive impacts should outweigh negative impacts) for all stakeholders in the delivery process. Changes may be incremental at the product level or radical if system shifts are needed." (Charter and Tischner, 2001, p. 130)*

The status of developments in areas such as changing consumption patterns and the creation of markets for sustainable products and services were included in the background research for this project, but are not within the scope of the research project presented.

1.2.3 "Specific" Problem Statement and Research Project

This research focuses on one aspect of the "Sustainable Solution" – the development of sustainable offerings (whether they are products, services or PSS, i.e. products and/or services) in industry. In particular, the research project focuses on the development of a TBL focused approach for industry for Sustainable Product and/or Service Development (SPSD) (Maxwell and van der Vorst, 2003). The SPSD term and approach is new, an evolution of SPD, and was created from this research to apply to the development of sustainable offerings. The research literature review and interviews with policy makers, academic and industry practitioners determined that no mainstream TBL

focused industry implementation method for developing sustainable offerings existed, with some related approaches starting to be developed. Based on a critical assessment of existing concepts and approaches relevant to developing sustainable offerings and industry requirements, the SPSD approach was developed and tested in this research.

It is understood that industry approaches for developing products with reduced environmental impacts – Environmental Product Development (EPD) e.g. ecodesign or Design for Environment - are well developed with a significant volume and diversity of EPD approaches, methods and tools available to industry. EPD implementation in industry is still at an early stage, but growing, with Multinational Corporations (MNC), mainly in the electronics and automotive sectors e.g. *Philips*, *Xerox*, *Sony*, *BMW* and *Honda*, leading the way. This industry activity is mainly in response to existing legal drivers focused on reducing specific environmental impacts of certain products e.g. packaging, automotive and electronics. However, as the drivers for industry to move towards managing not just their environmental but their sustainability impacts increase, a requirement for an industry approach incorporating TBL sustainability for developing offerings with improved sustainability performance in terms of environment, social and economic issues was recognised.

Concepts for incorporating TBL sustainability into product development exist with some industry approaches and tools starting to be developed (Byggeth and Broman, 2000; Charter and Tischner, 2001; Simonsson and Barthel, 2002; Holmberg et al, 2000). The most relevant of these to SPSD is Sustainable Product Development (SPD). SPD is about incorporating sustainability into the development of products and services throughout their lifecycle (Hanssen, 1997; van Weenen, 2000; Byggeth et al, 2000; Charter and Tischner, 2001). The "Sustainable Development" part of SPD has in theory the TBL definition of achieving an optimum balance between environmental protection, social equity and economic prosperity (Elkington, 1997). There is also a growing range of concepts and approaches relevant to providing more sustainable offerings and a SPSD approach. These include systems and functional level thinking in offering development aiming to achieve more significant environmental improvements (Brezet et al, 2001; van Weenan, 1997;

Stahel, 2000) An example is consideration of meeting functional needs through alternatives to products e.g. where it is more sustainable to meet the functionality required by the provision of a service, or alternatively, some combination of a PSS (Goedkoop et al, 1999; Mont, 2001; Engelhardt and Hammerl, 2002). Early PSS focused tools are starting to develop, to include a method for developing PSS in a TBL context which is nearing completion (van Halen, 2004). Other relevant approaches are those providing guidance on incorporating environment and social issues in conjunction with traditional business considerations to improve TBL sustainability in industry in general e.g. Sustainability Management Systems and Corporate Social Responsibility (SIGMA, 2003; BITC, 2003).

While the SPD concept exists and related approaches are developing, SPD in practice is at a very early stage with TBL supports only starting to be considered, no mainstream implementation method available and formal implementation in industry rare (Mont, 1999; Charter and Tischner, 2001; Byggeth and Broman, 2000; Simonsson and Barthel, 2002; Holmberg et al, 2000). As such, development of an approach for effective SPSD implementation for industry was a key aim of the research project.

1.3 RESEARCH AIM AND OBJECTIVES

The main aim of the research is:-

RESEARCH AIM

- **Facilitate the development of sustainable offerings (e.g. products and/or services) by industry, through a Triple Bottom Line focused implementation approach for developing sustainable products and/or services which eliminate, or minimise adverse sustainability impacts, as well as incorporating industry requirements.**

In terms of "the big picture", this is expected to move manufacturing industry further towards sustainable development.

Based on the research aim, the more detailed objectives are summarised below.

RESEARCH OBJECTIVES

1. Understand the background and status relating to products and their sustainability impacts;

2. Review the literature and existing approaches available and substantiate the need for a new approach for developing sustainable products and/or services:-

   - ❑ Identify and review existing approaches relevant to developing sustainable products and/or services;
   - ❑ Identify industry drivers and current activities relevant to developing sustainable products and/or services.

3. Develop the criteria for effective SPSD implementation based on:-

   - ❑ Review existing approaches relevant to developing sustainable products and/or services;
   - ❑ Identify industry drivers and requirements for developing sustainable products and services;
   - ❑ Identify how manufacturing industry implement approaches relevant to SPSD;
   - ❑ Determine relevant factors for effective SPSD implementation.

4. Assess the extent to which existing approaches meet the criteria for effective SPSD implementation.

5. Develop a new framework approach to support the development of sustainable products and/or services based on the criteria and the results of the assessment;

6. Evaluate the new approach by implementing it on a live case study basis in a representative number of manufacturing industry companies;

7. Based on the case evaluations, revise and finalise the new approach;

8. Present the final analysis, discussion and conclusions of the research with recommendations for stakeholders.

Following a comprehensive literature review to understand the research problem, proposed solutions and existing status, existing concepts, approaches, methods and tools relevant to developing sustainable offerings (to include EPD and SPD) were critically reviewed to understand what was already in place and how they could be utilised in developing an SPSD implementation approach. In order to determine what was needed in this approach,

criteria for "effective" SPSD implementation, i.e. resulting in the production of offerings (e.g. products and/or services) with improved sustainability performance and meeting relevant industry requirements, were determined. Meeting industry requirements regarding SPSD and its implementation in a company (ies) was seen as key for any approach to be used in the first place. The criteria were determined based on a review of existing approaches, how industry implement them, industry requirements, drivers and factors for effective SPSD implementation using a diverse range of data sources. The existing implementation approaches relevant to SPSD were assessed to determine to what extent they met these criteria. This assessment also identified the new aspects required in the SPSD approach. Based on the effectiveness criteria identified and this assessment, a new approach for industry for the effective implementation of SPSD was developed. In order to see if this new approach was practicable as a support for developing products and/or services with improved TBL sustainability performance and met relevant industry requirements in practice, its application was evaluated on a live case study group of companies. Based on the evaluation results, the new approach was revised and finalised as an approach for industry to support the development of sustainable products and/or services. Based on the industry requirements and effectiveness criteria identified in the research, it was determined that the approach should be communicated in the form of an SPSD implementation guide as an additional research output. For this research the guide is defined as a strategic level, framework approach that can be implemented on a generic basis in industry with additional site-specific customisation as relevant.

1.4 CONTRIBUTIONS TO KNOWLEDGE

The main contributions to knowledge resulting from the research are:-

- Identification of internal and external criteria for effective SPSD implementation to incorporate industry requirements and result in the production of products and/or services with reduced sustainability impacts.
- Identification and critical assessment of existing approaches, methods etc. relevant to developing sustainable products and/or services against the criteria for effective SPSD implementation.
- Development of the new SPSD approach and guide for industry.
- Case evaluation data from live application of the SPSD approach that includes the results and experiences of implementing companies on using the new SPSD approach to develop sustainable products and/or services.

1.5 IMPORTANCE AND ORIGINALITY OF CONTRIBUTIONS TO KNOWLEDGE

The development of the new SPSD implementation approach is seen as an important development to move industry further towards sustainability. It is proposed that it is an important research contribution towards developing more sustainable offerings – be they products and/or services. This is one contribution towards reducing the current adverse sustainability impacts caused by products and their consumption.

In terms of originality, much research has been conducted on developing industry EPD approaches aimed at reducing the environmental impacts of products. However, less research has been conducted on reducing the more holistic adverse sustainability impacts, to incorporate not just environmental but also social and economic impacts, and industry approaches for developing offerings integrating all TBL aspects (Byggeth and Broman, 2000; Charter and Tischner, 2001; Simonsson and Barthel, 2002). In terms of implementation in industry, with the exception of some MNC and a small number of

innovative SMEs, EPD implementation is relatively new. In particular, most mainstream EPD approaches implemented in companies to date focus on eco (re)design – the process of reducing the environmental burden of an existing product. SPD implementation within industry is rare and formal SPD methods are only starting to develop with little implementation guidance (Mont, 1999; Byggeth and Broman, 2000; Holmberg et al, 2000; Charter and Tischner, 2001; Croner, 2001; ADL, 2001; Simonsson and Barthel, 2002).

According to Charter and Tischner:-

> *"Some companies have started ecodesign activities, but social and ethical aspects are not usually integrated into the product development process. At present, there is little guidance on the product implications of business sustainability and very little information on applying SPD"* (Charter and Tischner, 2001, p. 121).
>
> *"At present, there is no clear theoretical or practical framework as to what SPD means for companies within the industrialised world"* (Charter and Tischner, 2001, p. 126).

According to a UK *BSI* study on SPD type activities there is:-

> *"little direct evidence of environmental and social issues being considered together in an integrated fashion" (Simonsson and Barthel, 2002, p. 4).*

This research investigated and provides framework implementation guidance for industry to incorporate environmental, social, economic and other business considerations to support the development of sustainable offerings.

1.6 STRUCTURE OF THESIS

The structure and content of the thesis is summarised in **Box 1.1**.

Box 1.1 Thesis Structure and Content

SECTION I – INTRODUCTION AND BACKGROUND **Chapter 1: Introduction** **Chapter 2: Research Methods** **Chapter 3: Impact of Products on Sustainability**	Section I describes the introductory and background data. **Chapter 1** outlines the problem statement, research aims, objectives and contributions to knowledge. Presentations, conferences and papers associated with the research dissemination are listed in **Appendix 1** and the following published paper is included with the thesis:- □ *Developing Sustainable Products And Services*, Maxwell and van der Vorst, Journal of Cleaner Production, Volume 11, Issue 8, December 2003, pp. 883 -895, Received 18/11/02, Elsevier Press The research method is described in **Chapter 2** supplemented by **Appendices 2: Data Types 1-4** and **3: Questionnaires**. The problem statement is further elaborated in **Chapter 3**.
SECTION II – REVIEW OF EXISTING APPROACHES, DRIVERS AND INDUSTRY ACTIVITIES **Chapter 4: Review of Existing Approaches** **Chapter 5: Industry Drivers and Activities in Developing Sustainable Products and Services**	**Chapter 4** reviews the existing approaches relevant to developing sustainable products and/or services, supplemented by **Appendix 4: EPD Methods & Tools** and **Appendix 5: SPD Approaches**. This clarifies what approaches are already in place, substantiates the requirement for an SPSD approach and what approaches can be built upon. The industry drivers and activities relevant to developing sustainable products and services are described in **Chapter 5** supplemented with **Appendix 6: Documented Company Examples**. This clarifies the requirement for an approach for developing sustainable products and/or services and provides information on how industry implements existing approaches.

SECTION III – DEVELOPMENT OF SPSD CRITERIA AND ASSESSMENT **Chapter 6: Development of SPSD Implementation Criteria** **Chapter 7: Assessment of Existing Approaches against Criteria**	Having identified the existing approaches (**Chapter 4**) and current industry drivers and activities relevant to developing sustainable products and services (**Chapter 5**), this information is collated and analysed in conjunction with additional data sources to develop the criteria for effective SPSD implementation approaches in **Chapter 6**. **Chapter 7** describes the extent to which existing approaches meet these criteria.
SECTION IV - DEVELOPMENT AND EVALUATION OF A NEW APPROACH **Chapter 8: New Approach: SPSD** **Chapter 9: SPSD Case Study Evaluation** **Chapter 10: SPSD Guide**	Based on the SPSD implementation criteria and the results of the assessment, the new SPSD approach is developed and presented in draft form in **Chapter 8,** supplemented by **Appendix 7: Draft Sustainability Assessment Checklist**. The evaluation of the approach is described in **Chapter 9** and supplemented by **Appendix 8: SPSD Evaluation Case Study Information Collection Template** and **Appendix 9: SPSD Evaluation Case Study Examples**. Based on the evaluation results, the revised SPSD approach is presented as a guide in **Chapter 10**, with online supporting material (provided on an attached CD ROM).
SECTION V – DISCUSSION AND CONCLUSIONS **Chapter 11: Discussion** **Chapter 12: Conclusions**	**Chapter 11** evaluates the research findings. The research conclusions and recommendations for further actions are in **Chapter 12**.
REFERENCES	The references used in this thesis are listed in the **References** section.

The most exciting phrase to hear in science, the one that heralds the most discoveries, is not "Eureka!", but "That's funny..."
Isaac Asimov

CHAPTER 2: RESEARCH METHODS

2.1 INTRODUCTION

In order to conduct the research project, a research strategy, method and work programme was developed. The research questions, research methods used, the rationale for using them and any particular issues associated with their use for this research are described in **2.2 Research Strategy**. The research quality controls used to ensure the research was conducted to suitable quality standards are in **2.3 Research Quality Control**. The research methods were developed based on a range of sources to include discussions with PhD supervisors, similar research approaches successfully used previously and the research methods advocated by publications on social science research methods, in particular by Yin and Creswell.

2.2 THE RESEARCH STRATEGY

2.2.1 Definition of Research Questions

Further to the research aim and objectives detailed in **Chapter 1,** the first step in determining a suitable research strategy was to define initial research questions requiring investigation (Creswell, 2002; Yin, 2003) in order to meet the objectives. The initial research questions were redrafted several times during the initial research process, in particular following the initial literature review. This review enabled the research to be re-focused, clearer questions to be defined and provided an accurate basis for the research (Yin, 2003). A research "process" document detailing the evolution of the research aims,

objectives and strategy was maintained throughout the research project. The maintenance of the process document was pertinent from a quality control perspective as well as highlighting key research developments and contributions to knowledge made throughout the research.

The final version of the research questions are as follows. The overall or "grand tour" question (Creswell, 2002) which reflects the overall research aim is:-

GRAND TOUR QUESTION

How can an approach for developing sustainable products and/or services be implemented effectively in industry to result in the development of products and /or services that prevent, or minimise adverse sustainability impacts as well as incorporating industry requirements?

In order to answer the overall research question and meet the aim and objectives, the following research questions were defined to focus the research (Creswell, 2002):-

RESEARCH QUESTIONS

1. *What existing approaches relevant to developing sustainable products and/or services are available to industry?*
2. *Is there a need for a support for developing sustainable products and/or services?*
3. *What are the drivers for manufacturing industry to produce more sustainable products and/or services?*
4. *How does manufacturing industry implement approaches relevant to developing sustainable products and/or services?*
5. *What are the requirements of manufacturing industry to produce more sustainable products and/or services?*
6. *What is effective SPSD implementation and what are the factors relevant to effective SPSD implementation?*

7. *What are the criteria for effective SPSD implementation approaches to incorporate industry requirements and result in the production of products and/or services with reduced sustainability impacts?*
8. *To what extent do existing approaches meet the criteria for effective SPSD implementation?*
9. *Does the implementation using the SPSD approach result in the development of offerings (products, services or PSS) with TBL sustainability benefits (environmental, social and economic)?*

   Note: offerings with TBL sustainability benefits were defined as preventing, where possible, or minimising adverse sustainability impacts?
10. *What are the experiences and views of implementing companies as to the effectiveness and practical use of the SPSD approach as a support for the development of sustainable products and/or services?*

2.2.2 Unique Access

The researcher was working as an environmental practitioner during the PhD research managing a range of environmental support initiatives for industry to include an initiative to support manufacturing industry to incorporate environment into product and service development called *Environmentally Superior Products* (ESP). This facilitated unique and unrivalled access to companies, practitioners and policy makers relevant to the research topic and was taken into account in developing the research strategy. A summary of the ESP initiative is in **Box 2.1**. The researcher's role in ESP is to provide information, advice and an overall co-ordination role to companies implementing projects to improve the environmental performance of their products and services. Access to companies implementing projects to improve the environmental performance of their products and services provided real life data and experiences invaluable to the research proposed and enabling a unique contribution to original research.

One of the disadvantages of ongoing practical experience in the research topic can be the possibility of introducing bias through preconceived notions lacking a rigorous basis or objectivity. These potential disadvantages were acknowledged early on in the project and measures to minimise them were incorporated in the research method and quality control. Further information on these measures is provided in sections **2.2.3 Research Method** and **2.3 Research Quality Control**.

Box 2.1 Environmentally Superior Products (ESP) Initiative

ESP is an Irish government initiative providing financial and other supports (information, advice, mentoring and networking) to industry to incorporate sustainability (with a key focus on environment) in their product and/or service development process. The aim is to support companies to develop more sustainable products and/or services without compromising their functionality, quality, ability to manufacture or cost. This is an "Environmentally Superior Product". The aim of the initiative is to improve the sustainability and hence business performance of Irish industry through a more sustainable approach to product and/or service development.

The ESP initiative was launched in March 1999 in response to increasing legal and market pressures on manufacturing industry to reduce the environmental impact of their products. The initiative is still operating with over forty projects conducted to date. Companies participating in ESP are from a range of manufacturing industry sectors (e.g. electronics, IT, construction, packaging, furniture and timber) and play different roles in the supply chain (e.g. raw material, component or sub component suppliers to OEMs).

2.3 RESEARCH METHOD

Due to the nature of the research being largely exploratory in nature with limited existing research on Sustainable Product Development (SPD) in industry and the requirement for information from suitable informants, a **qualitative** rather than **quantitative** approach was chosen (Creswell, 2002). A research method was developed to investigate and answer the research questions. The overall aim of the research method was to enable a rigorous and reliable research approach which investigated and answered the research questions. The research was an iterative process. As the research questions evolved in the early research

stages the research method was updated to reflect these changes. This is consistent with the nature of qualitative research whereby the design develops during the course of the research (Creswell, 2002).

Due to the diverse nature of the research questions to be answered multiple research strategies were used to include semi structured interviews, literature review and case study research (Creswell, 2002; Yin, 2003). Due to the researcher's access to real life industry and practitioner information and experience, a participant observation (or action research) approach, whereby the researcher was able to practically access events or groups otherwise inaccessible (Yin, 2003) could be incorporated. These approaches involve testing ideas in practice and are carried out by a practitioner (Kemmis and McTaggert, 1988). From now on this approach is referred to as participant observation. This combination of factors resulted in an innovative research methodology combining a mixture of research techniques. The advantages and disadvantages of the research techniques developed were considered with the aim being to maximise advantages and minimise any disadvantages which could threaten the overall quality and rigour of the research.

An illustration of the main phases, objectives to be achieved and data sources used in the research method is in **Box 2.2**. Six main types of data sources were used as described in **Box 2.3**. A description of the key research phases follows this.

Box 2.2 RESEARCH PHASES AND OBJECTIVES	**DATA SOURCES**
PHASE 1: REVIEW OF BACKGROUND, EXISTING APPROACHES, DRIVERS AND INDUSTRY ACTIVITIES. **1. Understand the background and status relating to products and their sustainability impacts;** **2. Review the literature and existing approaches available and substantiate the need for a new approach for developing sustainable products and/or services:-** ❑ **Identify and review existing approaches relevant to developing sustainable products and/or services;** ❑ **Identify industry drivers and current activities relevant to developing sustainable products and/or services.**	Literature Data Types 1-4
PHASE 2: DEVELOPMENT OF SPSD CRITERIA AND ASSESSMENT 3. **Develop the criteria for effective SPSD implementation based on:-** ❑ **Review existing approaches relevant to developing sustainable products and/or services;** ❑ **Identify industry drivers and requirements for developing sustainable products and services;** ❑ **Identify how manufacturing industry implement approaches relevant to SPSD;** ❑ **Determine relevant factors for effective SPSD implementation.** 4. **Assess the extent to which existing approaches meet the criteria for effective SPSD implementation.**	Literature Data Types 1-4
PHASE 3: DEVELOPMENT AND EVALUATION OF A NEW APPROACH **5. Develop a new framework approach to support the development of sustainable products and/or services based on the criteria and the results of the assessment;** **6. Evaluate the new approach by implementing it on a live case study basis in a representative number of manufacturing industry companies.** **7. Based on the case evaluations, revise and finalise the new approach.**	SPSD Case Evaluation Companies
PHASE 4: ANALYSIS AND CONCLUSION **8. Present the final analysis, discussion and conclusions of the research with recommendations for stakeholders.**	

Box 2.3 Data Sources and Collection Methods

Literature

The literature review was designed to obtain reliable information on the specific research topic (developing sustainable products and/or services) and how it related to broader issues (Sustainable Development, sustainable and environmental management in industry, etc.). The literature review "framed" the research question (as Creswell notes this is typical for qualitative research projects (Creswell, 2002)) and provided the baseline context. A range of documentation to include academic, practitioner, industry, government and legal publications was reviewed as part of the literature review. The availability of data varied with much being available on Sustainable Development and ecodesign tools for example, but less on the SPD topic. Where a considerable volume of literature was available, every effort was made to ensure relevant and concise information was obtained. As the SPD topic is still relatively new, reliably selected World Wide Web information sources were also used. An initial comprehensive literature review was conducted at the early stages of the research to provide baseline data. This was continued and elaborated on throughout the duration of the research project.

Data Type 1

Data Type 1 are eight companies with established, documented experience in the implementation of approaches relevant to developing sustainable products and/or services:-

- *Xerox*
- *Philips Consumer Electronics*
- *Electrolux*
- *Rohner Textil AG*
- *Wilkhahn*
- *IKEA*
- *Johnson & Johnson Ltd.*
- *Interface Europe.*

The choice was based mainly on availability of well documented case experiences relevant to developing sustainable products and/or services. As relatively few well documented case examples are available this limited the choice. It should be noted that the available examples focused mainly on EPD activities, in particular ecodesign. This is because few examples of TBL focused SPD approaches were identified. Within those available, other factors determining the choice of companies were:-

- access to company personnel,
- representation of a range of industry sectors, company sizes and roles in the supply chain.

A diversity of industry sectors, company size and role in supply chain were identified as important to getting a representative data source. As most companies practicing approaches relevant to SPSD are large Original Equipment Manufacturers (OEM), this meant all but one of the Data Type 1 companies are large OEMs. One is an SME.

Data Collection Method

Existing documented literature on these case examples combined with information provided by company personnel were used to collect the data. Information was obtained through interview (semi structured) in person or via telephone and email using predefined questionnaires. Additional information was provided by company representatives via documents, websites, email and personal communication.

Data Type 2

Data Type 2 are seventeen additional companies practising approaches relevant to developing sustainable products and services (but not necessarily having well documented company examples as in the type 1 data sources), These also focused mainly on EPD activities, in particular ecodesign.

Data Collection Method

Their views were obtained through literature (where available), interview, in person or via telephone and email using the predefined questionnaire for companies.

Data Type 3

Data Type 3 are a wide range of specialists in activities relevant to developing sustainable products and services, to include practitioners, academics and policy makers. They represent:-

- Key SPD/EPD Research/Resource organisations;
- Policy organisations with SPD/EPD involvement;
- Consultancies involved with SPD/EPD.

The functions and applications of the specialists contacted vary, but all play a role in the overall aim of sustainability in business and industry. Experts were identified from a range of sources to include the literature review (having peer reviewed published papers, books etc.), experts speaking at relevant conferences, professional contacts of researcher and subsequent follow up with new contacts and referrals from experts. The identification of experts has been ongoing and elaborated on during the lifetime of the research project. Records of all contacts with consultees were maintained.

Data Collection Method

Their views were obtained through interview, in person or via telephone and email using predefined questionnaires.

Data Type 4

Data Type 4 are sixteen companies implementing approaches relevant to developing sustainable products and/or services and participating in the ESP initiative. These sources were used to determine industry requirements for SPSD only, as these companies were commencing SPSD type activities, but were not yet experienced in SPSD implementation. Their addition added diversity in terms of industry sectors, size and role in the supply chain as not all companies were OEMs and all are SMEs.

Data Collection Method
A semi structured interview with relevant company personnel based on a pre defined questionnaire was used to collect the data. Additional information was provided by company representatives via documents or websites.

Data Types 1 – 4 totalled 106 data sources. The details of the organisations[1] are summarised in Appendix 2.

SPSD Case Evaluation Companies
Ten companies and their respective supply chain companies participated as the SPSD evaluation cases[2].

Data Collection Method
Interviews, documentation and participant observation using a predefined template[3] were used to collect this information during the case evaluations.

The key phases in the research method are summarised as follows:-

2.3.1 Phase 1 and 2

The first three objectives to be met in Phases 1 and 2 are illustrated in **Box 2.2**. In order to meet these objectives, data were collected and analysed using the following techniques:-

- Literature review
- Consultation/interviews
- Participant Observation
- Case study research.

In particular, the use of case study research was seen as a suitable technique for gathering and analysing data as existing company experiences with approaches relevant to developing sustainable products and/or services were important to answering research questions 3-7. According to Yin, case study research is particularly suitable when a *"how or why question*

[1] This includes sector, size and supply chain role characteristics for the companies.
[2] See **Chapter 9**.
[3] See *Case Study Information Collection Template* in **Appendix 8**.

is being asked about a contemporary set of events, over which the investigator has little or no control" (Yin, 2003, p. 9).

Data Type 1 documented case examples of approaches implemented by companies relevant to developing sustainable products and services were used to research some of these experiences and obtain an understanding of existing approaches used in industry. This information was further elaborated by information provided by contacts within the company involved in the approach used, where available. This supplemented and validated the information gathered in the literature.

Due to the researcher's access to companies engaging in projects relevant to SPSD, consultation as well as participant observation to obtain the views and real life experiences of these companies was designed into the research approach. Consultation with Data Type 3 experts representing practitioners, academics and policy makers in order to obtain their views and experiences were also incorporated. This was particularly important for answering research questions 1 and 3-8.

2.3.1.1 Questionnaires, Email Surveys and Interviews

In addition to the documented company examples and other literature sources used, information was obtained either by a semi structured interview (Flick 1998), in person or over the telephone (where meeting in person was not possible), based on a predefined interview questionnaire or based on an emailed questionnaire survey. Further clarification as required was obtained. Additional information was also provided, where available, through documents, websites etc. In order to structure the information obtained from the consultees, questionnaires were developed and used as a guide for the researcher for obtaining the information. The questionnaires were developed to ensure that the required questions were asked. Care was taken to ensure that open ended questions were used as these are recommended as a way of ensuring that the actual view of the interviewee is obtained as distinct from the view the researcher wishes to hear, which could be obtained

from using leading questions (Yin, 2003). The templates for the interview questionnaire and email survey questionnaire are in **Appendix 3.**

The Phase 1 and 2 data collected from the literature review, documented case examples, interview, email survey and participant observation, provided much baseline data for the research project and the ongoing development and design of the research methods. This enabled the requirements for the research to be better understood and substantiated. This information is incorporated in many chapters of the thesis, in particular **SECTION I INTRODUCTION AND BACKGROUND** and **SECTION II REVIEW OF EXISTING APPROACHES, DRIVERS AND INDUSTRY ACTIVITIES.**

Having established the baseline information regarding the research topic and investigated the following in particular:-

- existing approaches, methods and tools relevant to developing sustainable products and/or services;
- drivers and requirements for developing sustainable products and/or services;
- how manufacturing industry implement approaches relevant to SPSD;

criteria were developed that were determining factors in achieving effective SPSD implementation. Not all the criteria were expected based on the initial research questions. As a result of this new information, the research method was reassessed and reworked. The feedback and rework of the research design was invaluable as it ensured real results were taken on board not just those which agreed with the original propositions and the research questions were suitably revised to reflect the new information. As advocated by Yin, this provides an important quality control in qualitative research (Yin, 2003). Based on the data collection, analysis and subsequent research redesign and investigation, key criteria relevant to effective SPSD implementation were developed.

The final objective of Phase 2 was to assess the extent to which existing approaches meet the criteria for effective SPSD implementation. A broad range of the approaches identified relevant to the implementation process for developing sustainable products and/or services were assessed against the criteria for effective SPSD implementation. The predefined assessment criteria enabled an objective, systematic review of the identified approaches. The aim of the assessment was to identify the extent to which the existing approaches met the criteria and what new aspects were required. The development of the criteria, assessment process and results are detailed in **SECTION III – DEVELOPMENT OF SPSD CRITERIA AND ASSESSMENT.**

2.3.2 Phase 3

The Phase 3 objectives to be met were as follows:-

- Develop a new framework approach to support the development of sustainable products and/or services based on the criteria and the results of the assessment;
- Evaluate the new approach by implementing it on a live case study basis in a representative number of manufacturing industry companies;
- Based on the case evaluations, revise and finalise the new approach.

The new SPSD approach that incorporated the previously identified key criteria and results of the assessment was developed. This new approach builds on the elements of the existing approaches which met the criteria and incorporates missing criteria identified to better meet industry requirements and aims to result in the production of products and/or services with reduced sustainability impacts. Based on one of the criteria being the requirement for an explicit focus on incorporating services and Product Service Systems as well as products, the Sustainable Product and/or Service Development (SPSD) term was created. The next step was to evaluate the new approach by implementing it on a live case study basis in a representative case study group of manufacturing industry companies. This case study approach was chosen as the suitable research technique. Section **2.3.2.1** describes the case

study research approach used. Based on the results of this evaluation, the draft SPSD approach was revised. Based on another of the identified criteria being the need for simple, pragmatic tools, the final format of the approach was developed and presented as a SPSD guide.

2.3.2.1 Case Study Research Protocol

A case study protocol to provide a structure for conducting the case study evaluation was developed. According to Yin, having the protocol is an especially effective way of dealing with and increasing the reliability of case studies. Further it provides a guide for the researcher which is seen as essential for multiple case studies for carrying out the data collection, doing analysis and reporting case studies (Yin, 2003). The protocol was designed to include the following elements in order to have a rigorous and methodologically sound case study design (Yin, 2003):-

Case Study Overview

- Case Study Aims
- Case study Questions

Data Collection Procedures

- Information to be obtained from case studies
- Criteria for interpreting findings
- Sources of Information
    - ⇒ Case study companies
    - ⇒ Participant Observation
    - ⇒ Semi structured interviews
    - ⇒ Researcher questionnaire
    - ⇒ Publications and other data sources
- Other issues
    - ⇒ Access to case study companies

⇒ Commercial confidentiality of data

- Case Study Database

Analysis Method

- Units of Analysis
- Criteria for interpreting findings
- Outcomes from criteria analysis
- Replication Logic
- Initial Explanations
- Rival explanations & investigation

Case study Report structure.

The objectives of the case study evaluation were to answer research questions 9-10. These were the case study questions defined for the case study research. There were no propositions defined as the case study was to evaluate the new SPSD approach. The units of analysis were the implementation of SPSD in companies using the SPSD approach. For this unit of analysis, company evaluation cases were required. Due to the researcher's access to companies interested in improving the environmental performance of their offerings, a representative group of companies were recruited to evaluate the SPSD approach. This was seen as an ideal opportunity to research the topic with these companies in real life situations. Companies were given the opportunity to participate as evaluation cases if they agreed to focus on improving TBL sustainability as distinct from environmental performance alone. Hence SPSD was evaluated on a representative test group of companies interested to focus on not just the environmental, but the sustainability performance of their offerings.

Multiple case examples were chosen as this is recommended as a more robust approach than a single case study and has more substantial analytic benefits as there is the possibility of direct replication (Yin, 2003). In order to have as representative a group of case

examples as were available, the selection criteria included diversity in manufacturing industry sectors, products and services, organisation sizes and roles in the supply chain. This was to prevent bias that might be introduced by evaluation factors only pertinent to one industry sector for example. Ten case studies were chosen for the evaluation. This was based on availability of interested participant companies as well as a larger number of case studies providing increased certainty of the results (Yin, 2003). The specific details of the case study companies are in **Chapter 9.**

The information required from the evaluation and the criteria for interpreting the information within the evaluation were defined[4]. The evaluation was conducted by implementing the draft SPSD approach in the case study companies to develop sustainable offerings. Typically these lasted for between 8 – 18 months and data were gathered over this time period. Evaluation cases were mainly conducted concurrently over the 2001-2003 time period.

Evidence for case studies typically comes from six sources to include documentation, archival records, interviews, direct observation and participant observation and physical artefacts (Yin, 2003). The sources of data and evidence collected during the case study evaluation included documentation, interviews, direct observation, participant observation and physical artefacts (e.g. the offering developed). As many sources of information as possible were used to ensure quality (Yin, 2003).

Due to the researcher acting largely as a co-ordinator/mentor in the SPSD case evaluations, participant observation as a data collection technique was feasible. Participant observation as is defined as:-

> *"a special mode of observation in which you are not merely a passive observer. Instead you may assume a variety of roles within a case study situation and may actually participate in the events being studied"* (Yin, 2003, p. 94).

[4] Details of the information, criteria defined and analysis method are in **Chapter 9**.

The advantages of participant observation as a source of evidence include the following:-

- *"the ability to gain access to events or organisations that is otherwise inaccessible to scientific investigation".*
- *"the ability to perceive reality from the viewpoint of someone "inside" the case study rather than external to it".*
- *"many have argued that such a perspective is invaluable in producing an "accurate" portrayal of a case study phenomenon"* (Yin, 2003, p. 94).

As the research was investigating SPSD implementation in industry, the ability to participate in projects relevant to SPSD was seen as a great opportunity to access real life SPSD implementation data and experiences that would significantly enrich the research. As one of the aims of the research was to develop an SPSD approach for industry, the use of real life company case study experiences and data was seen as especially pertinent. The key disadvantage is the potential bias that can be introduced due to the potential manipulation of events by the researcher and the potential for changed behaviour in those being observed brought about by the presence of the researcher. Further information on this and the measures to control this potential bias are detailed in section **2.3**.

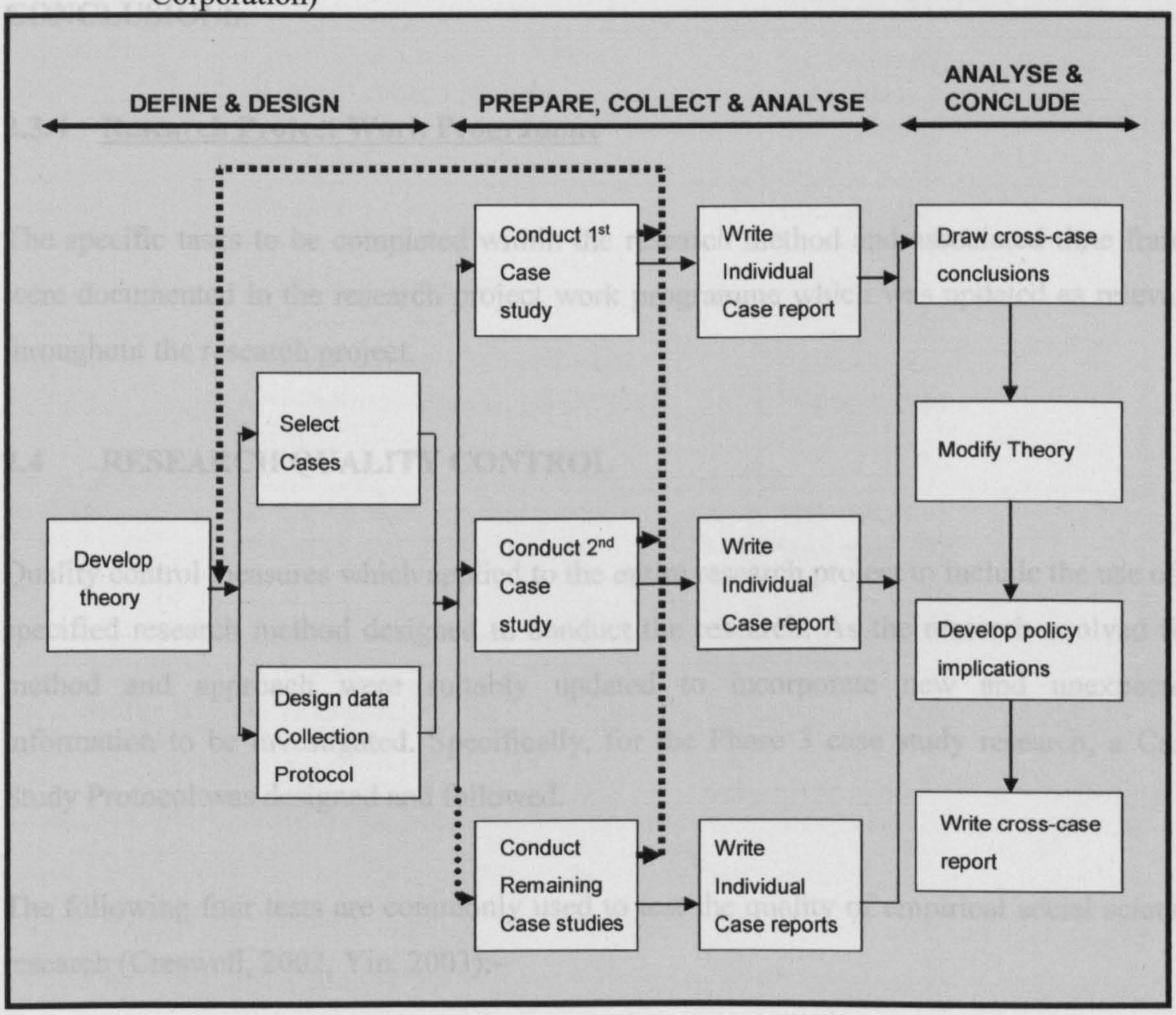
Through participant observation by the researcher as well as semi structured interviews with personnel involved in the case tests, the main information for the case study evaluation was obtained and recorded. Other sources were a case report prepared by the project team, the offering itself and additional information on the company from other sources e.g. documents. A predefined *SPSD Evaluation Case Study Information Collection Template*[5] was used as a guide for the data collection. A case study database of the data collected for each case study test was maintained.

The analytic strategy defining priorities for what to analyse, why and criteria for interpreting the findings were defined in the original protocol. This was seen as important for treating the evidence fairly, producing compelling analytic conclusions and ruling out alternative interpretations (Yin, 2003). As units of analysis, each case study was analysed

[5] See **Appendix 8.**

individually in terms of the defined criteria for interpreting the findings and for success and failure. Replication logic was used to show similar features or differences between case studies and to be a basis for generalising from the results of all case examples. Rival explanations for the findings were highlighted and investigated. This case analysis approach as well as the wider case study method followed is illustrated in **Figure 2.1**.

Figure 2.1 Case Study Method (reproduced from Yin, 2003, p. 50, Source: COSMOS Corporation)



Following the case study evaluation, the results were used to evaluate and finalise the draft method in light of the case study experiences. The ability to evaluate the use of the draft SPSD approach in real life company case scenarios was seen as extremely effective to the review and subsequent completion of the SPSD guide. The case study evaluation process

and results from Phase 3 of the research are documented in **SECTION IV DEVELOPMENT AND EVALUATION OF THE NEW APPROACH.**

2.3.3 Phase 4

Phase 4 was to present the final analysis, discussion and conclusions of the research and recommendations. This is documented in **SECTION V DISCUSSION AND CONCLUSIONS.**

2.3.4 Research Project Work Programme

The specific tasks to be completed within the research method and associated time frame were documented in the research project work programme which was updated as relevant throughout the research project.

2.4 RESEARCH QUALITY CONTROL

Quality control measures which applied to the entire research project to include the use of a specified research method designed to conduct the research. As the research evolved the method and approach were suitably updated to incorporate new and unexpected information to be investigated. Specifically, for the Phase 3 case study research, a Case Study Protocol was designed and followed.

The following four tests are commonly used to test the quality of empirical social science research (Creswell, 2002, Yin, 2003):-

- Construct Validity
- Internal Validity
- External Validity
- Reliability.

For each test, **Table 2.1** illustrates the case study tactic adopted for quality control and phase in which it was used.

Table 2.1 Case Study Tactics for four quality control tests (reproduced from Yin, 2003, p.34, SOURCE: COSMOS Corporation)

Tests	Case Study Tactic	Phase of research in which tactic occurs
Construct Validity	•Use multiple sources of evidence •Establish chain of evidence •Have key informants review draft case study report	Data collection Data collection Composition
Internal Validity	•Do pattern-matching •Do explanation-building •Address rival expectations •Use logic Models	Data analysis Data analysis Data analysis Data analysis
External Validity	•Use theory in single-case studies •Use replication logic in multiple-case studies	Research design Research design
Reliability	•Use case study protocol •Develop case study database	Data collection Data collection

The measures taken to incorporate these four tests in the research are detailed in below.

Construct Validity relates to specifying correct operational measures for the concepts being studied (Yin, 2003). Overall the *construct validity* was dealt with by designing a research method. Within the research method, the concepts being studied were defined in the research aim, objectives and the study questions. The selected measures of these concepts were also defined in the research method. To demonstrate that the selected measures of these concepts do indeed reflect the specific concepts, the following approaches were used:-

- Use of multiple, not single sources of evidence;
- Establishment of a chain of evidence.

Multiple, not single sources of evidence were used to obtain information especially in the data collection phases of the research. These sources of evidence included documents, interviews, participant observation and physical artefacts (in the form of offerings resulting from the case evaluations). The intention behind the use of multiple sources of evidence was to validate one source with another, as available, in order to encourage convergent lines of inquiry (Yin, 2003) where these existed.

The establishment of a chain of evidence addresses the problem of determining *construct validity* as well as increasing the *reliability* of information generated. A clear chain of evidence was maintained throughout the research project to include the definition of the research methods, maintenance of records from data collection, analysis and conclusions. In particular, for the case study tests, the use of a case study protocol (to document the overall case study research process), case study database (to document the data collected) and case study reports (to document the analysis and final results) provide a chain of evidence leading from the case study questions to the conclusions.

The aim of reliability is to minimise the errors and biases in a study (Yin, 2003). Every effort was made to ensure the *reliability* of the data collection and analysis. This included using multiple sources of evidence where available to corroborate data. In terms of the development of questionnaires to guide the researcher in interview, open ended questions were used and leading questions avoided, in order to get the real view of the interviewee, as distinct from the researchers. Notes were taken during interviews and answers confirmed verbally with the interviewee to confirm accuracy. As a result of the researcher's participant observation role in the case tests most information was provided freely and frankly by participants within agreed confidentiality constraints.

As the case study evaluations lasted approx. 8 – 18 months there was much opportunity for accessing data through participant observation over an extended time and in different conditions. This was seen as a positive influence on the *reliability* of the data obtained. Participant observation as a source of evidence and data collection technique has many

advantages but also one particular disadvantage in that potential biases can be introduced due to the researcher's manipulation of events (Yin, 2003). The example is cited of the researcher potentially becoming a supporter of a phenomenon being studied where such support did not already exist (Yin, 2003). Hence a lack of objectivity can occur.

To reduce potential bias in phase 1, multiple information sources in addition to participant observation were used to include interviews with case project managers, case reports, final offering and additional case information. To reduce the potential bias in the case study phase of the research, specific criteria for interpreting the results of the case study evaluation were defined and used throughout the case study evaluation. This was to prevent the researcher from introducing new criteria determined during the evaluation that may not be objective. These two measures together were seen as counterbalancing the potential bias due to participant observation.

In determining causal relationships, one of the key *internal validity* issues which can arise is incorrect inference that a result was caused by some occurrence based on a source of information e.g. interview or document. Also bias can be introduced by preconceived notions of the researcher. To address these issues, the following measures were used:-

- Again the use of multiple information sources to validate information from different sources. In particular, direct observation through the participant observation approach facilitated the corroboration of data identified through interview and vice versa.

- As the researcher was already an experienced environmental practitioner, potential for bias being introduced by preconceived notions was recognised. Much time was spent at the early research stages with the supervisor in clarifying the differences between research and consultancy projects and the importance of an open minded, reliable rigorous approach in academic research. The researcher endeavoured to be sensitive to preconceived notions and responsive to contradictory evidence throughout the research project. Discussion with supervisors and other consultees throughout the project to

obtain alternative explanations for results helped to manage this potential bias (Yin, 2003). In the case study evaluation phase, the case study protocol includes the investigation of rival explanations as well as expected explanations to facilitate additional possibilities being considered.

In terms of external validity, the first point to note is Creswell's view that while qualitative research is intended to form a specific interpretation of events rather than to generalise findings, a limited generalisation to highlight the resulting themes is acceptable (Creswell, 2002). Secondly, in applying generalisation to the results of the case study evaluation of the SPSD approach, replication logic was applied to the multiple case studies to address external validity (Yin, 2003).

"The world has enough for everyone's need, but not for everyone's greed."
Mahatma Gandhi

CHAPTER 3 : IMPACT OF PRODUCTS ON SUSTAINABILITY

3.1 INTRODUCTION

The overall research problem, the potential solutions proposed and how they relate to this research project were introduced in **Chapter 1**. For background information, this chapter presents a more detailed description of the overall research problem in terms of the environmental and social impacts associated with the production and consumption of products.

3.2 ENVIRONMENTAL AND SOCIAL IMPACTS

The production and consumption of products have adverse environmental and social impacts (EC, 1998; EC, 2000; EC, 2001; UNEP I& E et al, 1997(a); UNEP WG SPD, 2000; UNDESA, 2002; EC, 2003; DEFRA, 2003; Davidsson, 20002; Tischner and Charter, 2001; Klein, 2001; Elkington, 1997, WWI, 2004). Looking at consumption and production in general, the 2002 World Summit on Sustainable Development, highlighted current patterns of consumption and production as unsustainable and resulting in adverse environmental and social impacts (UNDESA, 2002). This relates to both the production of products (the demand side) as well as their consumption by consumers (the supply side) and the interrelation between both sides (UNDESA, 2003).

Adverse sustainability impacts can occur at many stages of the product lifecycle - raw material acquisition, production, distribution, use and end of life reuse, recycling, treatment or disposal. The adverse environmental impacts associated with the production and consumption of products are well know. These are outlined in **3.2.1** below. These impacts can be exacerbated by other factors e.g. high population, high product consumption rates due to high consumer demand, global trade patterns, technological development and

quickly changing consumer preferences. The extent of environmental damage caused is largely dependant on the type of product and the volume produced. In today's developed world, we manufacture a wide range of products in high volumes to satisfy increasing consumer demand and high population levels. In 2000, Datschefski estimated that approximately 100 million products were on sale worldwide (Datschefski, 2000). The world's passenger car fleet is estimated at over 531 million, growing by 11 million vehicles per annum (WWI, 2004). One quarter of the global population (1.7 billion people) are part of the global consumer class[1] (WWI, 2004). Rapid technological development and quickly changing consumer preference can compound this problem by resulting in a high turnover of products which become quickly obsolete. A classic example of this is the fast moving ICT, telecommunications and electronics industries where new models of mobile phones and IT equipment, to name a few, replace their previous counterparts within months. An example of one of the adverse environmental impacts for these industries is the rapidly growing electronics waste stream – identified as one of the fastest growing waste streams in the EU (EC, 2000).

At present population and product consumption levels, it is already clear that the environment cannot sustain these adverse environmental impacts (Aloisi de Larderel, 2001; UNDESA, 2002).

> *"Regardless of recent efficiency improvements in the development of products and services, a growing population and the emergence of a dynamic global consumer culture are fuelling environmental deterioration"* (Aloisi de Larderel, 2001, p. 15).

In particular, due to the earth's finite resources, material and energy consumption associated with product manufacture and use are seen as key areas for achieving sustainability (Croner, 2000). In particular, increasing efficiencies in material and energy consumption towards a "dematerialisation" of products (reducing the material and energy inputs) has been advocated for some time (van Hemel, 1998). Large reductions in material and energy consumption of the order of a factor 10-50 are advocated in order to support the sustainable consumption of goods and services for a global population that is forecast to reach 8 billion by 2040 (Cramer, 1997; Croner, 2000; Charter, 1999; European Foundation,

[1] Using products e.g. TVs, telephones and the internet.

1997; Hawken et al, 1999; Foxon et al, 2003). In light of a growing world population, it is estimated that:-

> *"industrialized world reductions in material throughput, energy use and environmental degradation of over 90% will be required by 2040 to meet the needs of a growing world population within the ecological means of the planet"* (Euro Foundation, 1997, p. 23).

There are not only adverse environmental problems associated with production and consumption, there can also be adverse ethical & social issues such as child labour, inequitable distribution of resources, inequitable trading policies, etc. (Tischner and Charter, 2001; WWI, 2004). This is increasingly coming to light as an issue in line with globalisation and the increasing sub-contract market in the developing world. In contrast to the 1.7 billion humans in the consumer society, 2.8 billion consume too little, suffering from poverty, hunger and homelessness (WWI, 2004). The social impacts associated with the production of products are outlined in **3.2.2**.

3.2.1 Environmental Impacts

Many of today's environmental problems e.g. climate change, waste generation, pollutant emissions to air and water, biodiversity loss and depletion of natural resources are being attributed to unsustainable patterns of production and consumption largely in the industrialised or developed world (UNDESA, 2002; Davidsson, 2002; EC, 2003; DEFRA, 2003) .The EU Integrated Product Policy 2003 Communication summarises this as follows:-

> *"The manufacture, use and disposal of products are the cause of many of the environmental challenges we are facing today. The quantity of products is rising, partly due to increases in disposable income and smaller households e.g. many more people own cars today than 20 years ago. Products also come in many more shapes and sizes as a result of rapid innovation and global trade patterns, and are becoming increasingly complex" (EC, 2003, p. 2)*

Some additional views are:-

> *"Looking at products closely highlights the environmental problems they cause. Over 30 tonnes of waste are produced for every one tonne of product that reaches the consumer. And then 98% of those products that do reach the end consumer are thrown away within 6 months. This whole process is about 2% efficient in terms of energy."* (Datschefski, E., 2000, p4)

> *"We are far better at making waste than at making products. For every 100 pounds of product we manufacture in the United States, we create at least 3,200 pounds of waste. In a decade, we transform 500 trillion pounds of molecules into non productive solids, liquids and gases."*
> *Author, environmentalist, and board member of The Natural Step/US, Paul Hawken (*TNS, 2000, p.7)

Significant depletion of resources, in terms of material and energy in the developing world, has been attributed to raw material acquisition for production in the developed world in addition to the environmental problems of waste and pollution which can be associated with raw material acquisition (European Foundation, 1997 and 1997a).

> *"While representing 20% of the world's population, the West uses 80% of annual extracted and exploited material and energy resources"* (European Foundation, 1997, p. 23).

Some statistics relating to resource depletion attributed to production and consumption based on the UNEP/SETAC Life Cycle Initiative are as follows:-

- If present consumption patterns continue, two out of every three persons on Earth will live in water-stressed regions by the year 2025.
- Exposure to hazardous chemicals has been linked to numerous adverse effects on humans ranging from birth defects to cancer. Each year, the use of pesticides results in 3.5 to 5 million acute poisonings around the world.
- The number of cars per 1,000 people in the developing countries rose from eight in 1975 to 16 in 1993, and from 289 to 405 in the industrialised countries. During the same period, average annual petrol consumption rose from 21 to 43 kg per capita in the developing countries, but fell from 554 to 500 kg per capita in the industrialized countries.

- Steel consumption has increased dramatically in recent years, from 602 million metric tonnes in 1992 to 693 tonnes in 1997.
- Paper consumption per capita has increased substantially everywhere except sub-Saharan Africa, where it has fallen in the past 30 years. The industrialised countries use 87 percent of the world's writing paper, almost 16 times as much per person as in developing countries (Fava and Saur, 2002; UNEP, 2002a)

It would appear that the *"industrialized world has already used a lot of its environmental credit"*. (European Foundation, 1997, p. 12)

3.2.1.1 Which Products and Services Cause the Biggest Problems?

More information is required on the environmental impacts associated with specific products and services as well as their lifecycle stages to highlight those posing the biggest sustainability challenges (EC, 2003; Davidsson, 2002; UNEP, 2002a). The IPP work programme currently includes identifying and prioritising strategies for those products that are the most problematic environmentally (Goodchild, 2004). Within this, a project is underway to identify by 2007 products with the greatest potential for environmental improvement in the EU (Tukker, et al, 2004). The EC "Study on External Environmental Effects Related to the Life Cycle of Products and Services Final Report" identifies the external environmental impacts generated in the EU, of the product and service categories constituting most of the European economy (EC, 2003c). For the purposes of that study, the products and services included were classified as final products and services (not including intermediary products) corresponding to major consumption expenditure in the European economy and transversal activities, products or services common to most of the final products. The products and services considered are listed in **Table 3.1**.

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Table 3.1 Products and Services considered in EC "Study On External Environmental Effects Related To The Life Cycle Of Products And Services Final Report" (EC, 2003c)

FINAL PRODUCT CLASSIFICATION
Food and beverages
Vegetables
Food from animals
Alcoholic beverages
Clothing and footwear,
Textile (apparels and non domestic textiles)
Footwear (leather)
Housing
Building structure (residential)
Domestic appliances
Building occupancy (residential sector) (heating, hot water, ventilation, domestic appliances, lighting)
Water (supply and waste water treatment)
Municipal Solid Waste (MSW) management (recycling, incineration, landfill)
Furniture
Cleaning agents
Healthcare and body care
Personal care products
Baby products
Medicines and pharmaceuticals
Transport
Public transport (road, rail, water, air)
Personal cars
Communication, recreation and culture
Information technology equipment
Paper products
Games & toys
Gardening
Jewelry
Restaurants & hotels
Other services
Other products and services
Machinery, equipment & apparatus
Other products
Other services
TRANSVERSAL ACTIVITIES, PRODUCTS OR SERVICES COMMON TO THE FINAL PRODUCTS OR SERVICES
Electric and electronic products and equipment
Domestic appliances
Information technology equipment
Construction work
Building structure (commercial and residential)
Civil work (roads and other infrastructures)
Building occupancy
Residential sector (gas, fuel, electricity, biomass)
Commercial sector (gas, fuel, electricity, biomass)
Packaging
Food (glass, paper, plastics, metals…)
Non food (glass, paper, plastics, metals…)

Textile
Apparel
Home furnishing
Industrial and non domestic uses
Transport
Public transport (road, rail, water, air)
Personal cars
Goods transport (road, rail, water)

The contribution of the different categories to environmental impacts at EU level for specified environmental impacts are listed in **Figure 3.1**.

Figure 3.1 Contribution of the Different Categories to Environmental Impacts at the EU Level (Source: Reproduced from EC, 2003 c, p. 85)

	Contribution of categories to total EU Impacts				
	10-20%	**21-40%**	**60-80%**	**40-60%**	**>80%**
A1 Environmental Impacts					
Depletion of non-renewable resources	EEE	**Bulding occupancy** Transport			
Greenhouse effect					
Air Acidification					
Ozone Depletion		Bulding occupancy		**Transport**	
Photochemical Oxidation	Building occupancy	**Transports** Food products			
Eutrophication	Water Supply		**Food products**		
Human Toxicity	Packaging		**Water Supply**		
Years of life lost	EEE	Bulding occupancy		**Transport**	
Aquatic Ecotoxicity	Packaging		**Water Supply**		
Sediment Toxicity					
Terrestrial Toxicity		**Bulding occupancy** EEE			
B1 Other Environmental Indicators					
Primary Energy		**Transport** Building occupancy			
Dusts	EEE Transport	**Bulding occupancy**			
Dioxins		**MSW mgt.** Packaging Transport EEE			
Metals into air		EEE		Building occupancy	
Metals into water					
Metals into soil		Transports Water Supply		**MSW mgt.**	
Municipal and Industrial Waste					**MSW mgt.**
Hazardous Waste		MSW management		**Packaging**	
Inert Waste				**Civil Work** Building Strucutre	

Key: In **Bold** characters = the most significant category for each impact.
EEE = Electrical & Electronic Equipment; MSW = Municipal Solid Waste; Mgt = management

The EC study concluded that most of the environmental impacts linked to resource consumption and air emissions were generated by the following two main product categories, for which the use lifecycle stage causes the greatest impact:-

- "transport" (goods transport and private transport of passengers by car),
- "building occupancy" (mainly due to the energy used to heat domestic and commercial buildings).

Environmental impacts associated with other categories were determined as:-

- "Food products" production generates most of the water emissions contributing to eutrophication (mainly from "vegetables" due to the use of fertilisers) and photochemical oxidation (mainly from "food from animals" due to enteric fermentation and manure management).
- The main categories contributing to toxicity and ecotoxicity risks are different according to the type of toxicity considered and for human toxicity risk are "water supply" (mainly due to sewage sludge (end of life step) associated with "waste water treatment").
- Terrestrial ecotoxicity mainly originates from "building occupancy" and "EEE" (due to electricity consumption during the use stage).
- Solid waste is generated from the "MSW management" category (municipal and industrial waste) as well as "civil work" and "building structure" categories (inert waste). (EC, 2003c, p. 9).[2]

Adding all the categories analysed, the lifecycle stage contributions for the environmental impacts highlight that the:-

- environmental impacts linked to resource consumption and air emissions are mostly generated during the use stage,
- eutrophication is mainly linked to the production stage,

[2] This study notes that the results are limited by the LCA data available and the classifications that were necessary (EC, 2003c).

- human toxicity, ecotoxicity risks and solid waste are split between use stage and end of life stages (EC, 2003c, p. 82).

Figure 3.2 summarises the main environmental impacts associated with the use, production and end of life stages for all the categories analysed.

Figure 3.2 Environmental Impacts Generated at EU Level – Summary of Life Cycle Stages Contribution (Source: reproduced from EC, 2003 c, p. 83).

Main LC stage contributing to the impacts	Main impacts & environmental indicators concerned
Use stage	Depletion of non renewable energy, including primary energy
	Impacts linked to air emissions: Greenhouse effect, Ozone depletion, Air acidification, Photochemical oxidation, metals, dusts
	Metals into water
	Metals into soil
	Years of life lost (human health)
	Terrestrial ecotoxicity
Production stage	Eutrophication
	Hazardous waste
End of life stage	Dioxins into air
	Human toxicity
	Aquatic and sediment ecotoxicity
	Municipal, industrial and inert waste

Early indications from an *European Environment Agency* study, in progress, analysing household related consumption in the EU, are that the most significant environmental impacts are associated with food, housing and transport with areas of growing impact from powered goods and tourism, both due to a combination of the scale of consumption and the seriousness of the environmental impacts (EEA, 2003). The US based *Union of Concerned Scientists* identified a similar range of consumer activities adversely impacting the environment for the USA (Union of Concerned Scientists, 2004).

Specific products have been targeted by legal and market drivers (in particular in the EU) to reduce their environment impact as this impact has been deemed as significant, in particular due to the significant volumes of these products consumed as well as their environmental impact[3]. These include:-

- Packaging (mainly to reduce end of life waste) (EC, 1994);
- Vehicles (mainly to reduce end of life waste, in particular hazardous waste and vehicle emissions (EC, 2000a; EC, 1999a; EC, 1999b; EC, 2000c; EC, 2000d);
- Electrical and Electronic Equipment (EEE) (mainly to reduce end of life waste and in particular hazardous waste) (EC, 2003a; EC, 2003b);
- Energy using Products (mainly to reduce energy use and contribution to climate change) e.g. electric motor systems, office equipment and lighting - currently the subject of draft legislation (EC, 2003d).

Taking vehicles as an example, their environmental impacts include emission of CO_2, hence contributing to greenhouse gas emissions and climate change (cars are currently responsible for approximately 80% of CO_2 emissions in the UK), other pollutant emissions to air, resource use, land usage for roads and parking as well as waste generation (DEFRA, 2002). Global car travel (in person miles per year) is projected to triple from 1990 – 2050 and the transport sector is the fastest growing and most intractable source of CO_2 emissions (approx. 21 % of the global energy related total) (Hawken et al, 1999).

For EEE, significant environmental impacts include resource use in terms of materials and energy, contribution to greenhouse gas emissions and hence climate change, generation of waste and release of hazardous substances to the environment (EC, 2003d). Raw materials can include metals mined from ores, plastics (usually produced from non-renewable petrochemicals) and quantities of precious metals (e.g. gold in some semiconductors or palladium in mobile phones) (DEMI, 2003). The environmental impacts associated with extraction and processing can be significant (1 to 350,000 ton ratio of material to waste)

[3] The specific legal and market drivers aimed at reducing the environmental impacts of these product types are discussed in **Chapter 5.**

(von Weiszacker et al, 1996). During use, energy usage and contribution to greenhouse gas emissions and hence climate change are key significant impacts. According to the *International Energy Agency*, in the OECD, residential electrical appliances and equipment (e.g. white goods, Information & Communication Technologies (ICT) domestic goods i.e. computers) are the second largest consumer of electricity after vehicles (using 30% of all electricity generated in OECD countries) and third largest emitter of greenhouse gas emissions (produce 12% of all energy related CO_2 emissions) . Demand for these appliances is projected to grow 13% by 2010 and 25% by 2025 (IEA, 2003). Further, the German *Environment Agency*, calculates that €3.5bn annually is currently wasted by appliances left on stand-by mode or not unplugged from the mains, equivalent to 14m tonnes of CO_2 emissions (ENDS, 2004). In the UK, EEE account for just under 20% of domestic energy use (which is 25% of total UK energy use), with the largest user being domestic heating. For the UK, the percentage of domestic energy consumption for the following product categories is as follows:-

⇒ Lighting: 25% (of domestic energy consumption);
⇒ Cold Appliances: 24%;
⇒ Wet Appliances: 13%;
⇒ Cooking appliances: 19%;
⇒ Brown goods (e.g. TVs, videos): 12%;
⇒ Miscellaneous/Small appliances: 7% (DEMI, 2003).

In the commercial sector, the energy consumption of EEE is mainly due to lighting (accounts for 14%), computers (for 10%) and other office equipment (7%) (DEMI, 2003). For offices, the largest consumers of energy are photocopying machines, followed by monitors and printers (TNO, 1998). At end of life, electrical products contain a large number and diversity of materials to include potentially hazardous substances e.g. Mercury, Cadmium and Lead in solders on Printed Circuit Boards:-

> *"The waste stream of electrical and electronic equipment has been identified as one of the fastest growing waste streams in the EU constituting 4% of the municipal waste today, increasing by 16-28% every five years – three times as fast as the growth of average municipal waste. Furthermore, it is one of the largest known*

> *sources of heavy metals and organic pollutants in the municipal waste."* (EC, 2000, p.2).

It is important to note that the environmental impact of production and consumption is not just a function of the specific environmental impact and its significance. Other factors e.g. the volume of products and services consumed are important in determining the environmental impact of production and consumption. In some cases, improved environmental efficiencies in products (e.g. greater energy or materials efficiency) can be negated by increases in the volume of product consumed (Davidsson, 2002). This is a rebound effect and has been identified in the UK economy for the following products:-

- Cars;
- Washing machines;
- Dishwashers;
- Cold appliances (including fridges, freezers and fridge freezers);
- Videos (DEFRA, 2003).

Despite environmental efficiency improvements in all these products in recent years, the increase in the volume of UK consumer purchases and use of these products has outstripped the efficiency gains (DEFRA, 2003). Broadening this out to Europe and North America, over the last 20 years energy efficiency initiatives have reduced energy intensity per unit of GDP by more than 25 % . However, this improvement in efficiency per unit of production has been offset by an increase in the volume of goods and services consumed and discarded (Fava and Saur, 2002).

3.2.2 Social Impacts

There are not only adverse environmental problems associated with production and consumption. There can also be adverse ethical and social impacts. These include unethical labour practices (e.g. child labour, forced labour, discrimination and unequitable wages), human rights violations, hazardous working conditions, inequitable distribution of resources and inequitable trading policies (Tischner and Charter, 2001; Klein, 2001;

Elkington, 1997, WWI, 2004). In terms of child labour alone, the International Labour Organisation (ILO) estimate that 246 million children between 5 and 17 years of age are working as child labourers with most of these in Asia (60%) and Africa (32%) (ILO, 2000). Of this, approximately 70% are working in production related sectors to include manufacturing, wholesale/retail, transport, construction, mining/quarrying, agriculture/fishing/hunting (ILO, 2000). In particular, environmental degradation in itself is highlighted as an increasingly important causal factor in social instability and limiting developing country's social progress (Hawken et al, 1999, DEFRA, 2003). Significant environmental problems e.g. drought, flooding and loss of resources are increasingly resulting in social problems, with increasing numbers of refugees arising from ecological disasters (Hawken et al, 1999). Further, limited access to declining resources is considered to be an increasing factor in conflict generation. This threat increases as the per capita availability of resources – land, water, fish, energy sources etc. continues to decline (Hawken et al, 1999). Sustainable Consumption and Production (SCP) policies have highlighted that SCP is linked to poverty eradication and social progress in the developing world (DEFRA, 2003; UNDESA, 2002)

Social and ethical impacts of production and consumption are increasingly coming to light in line with globalisation facilitating global raw material sourcing and product supply, international product supply chains having increased sub-contract activities in the developing world as well as the *CNN* and internet world of rapid media communication (Hawken et al, 1999; Elkington, 1997; Tischner and Charter, 2001). The drive for competitive advantage in order to maximise profit is the main driver for production activities moving to the developed world. According to WBCSD Director and Special Advisor to the UN Global Compact, Claude Fussler:-

> *"We thought human rights were only the territory for government action. But consumers and investors now also judge how companies deal with sweatshops, zones of conflicts or HIV/AIDS around their global operations"* (Sullivan, 2003a, p. 16.)

Another aspect is that consumers are insulated from the social impacts of their purchases due to the increasing distance between where the product is made and later used (WWI, 2004).

Recent high profile cases of employee exploitation in terms of sweatshop conditions, child labour, cheap labour and hazardous working conditions within the *Gap* (Munk, 1998) and *Nike* (Global Exchange, 1998; Nike, 1999; Nike, 2001, 2002) developing world sub-contract chains, or *Shell's* oil exploration in Nigeria or controversy over food ethics and GMOs all illustrate the diversity of emerging social and ethical issues (Klein, 2000; Mont, 2001; Tischner and Charter, 2001; Sullivan, 2003a). Such cases have increased interest from a growing range of ever less trustful stakeholders, in particular consumers and NGOs, about a product's point of origin and associated conditions (Klein, 2000; Leipziger, 2003, Solgard, 2000). Increasing environmental and social awareness of customers is growing, albeit slowly (Solgard, 2000; MORI, 2000). Data from the *UNEP Sustainable Consumption* (SC) programme (Solgard, 2000) and the *First European Survey of Consumers' Attitudes towards Corporate Social Responsibility* (MORI, 2000) illustrate an increase in consumer awareness on the environmental and social issues associated with products. An *Environics* survey highlights that 2 in 3 citizens want companies to go beyond making profits, employing people and obeying laws to contributing to broader societal goals (Environics, 2001).

A range of cases illustrate the social and ethical impacts which can be associated with producing products. Naomi Klein illustrates this well when she highlights that:-

> *"the travels of Nike sneakers have been traced back to the abusive sweatshops of Vietnam, Barbie's little outfits back to the child labourers of Sumatra, Starbucks' lattes to the sun-scorched coffee fields of Guatemala, and Shell's oil back to the polluted and impoverished villages of the Niger Delta"* (Klein, 2000, p. xviii).

To take the example of sweatshops and inequitable working conditions, the sweatshop profiles for a range of products are outlined in **Table 3.2**. This illustrates a range of social impacts to include poor employee working and living conditions, health and safety, wage rates, lack of pay, forced labour, discrimination, lack of contracts, benefits and codes of conduct.

Table 3.2 Sweatshop Profiles (Source: Modified from Klein, 2000, p. 486)

Company/Label	Factory in China	Wages per hour	Hours per week	Condition
Wal-Mart/Kathie Lee handbags	Liang Shi Handbag Factory	$0.13 to $0.23	60-70; 10-hour shifts; 6-7 days a week	No factory fire exits; dirty, cramped dorms, 10 to a room; for 70 hours a week, warehouse workers earn $3.44; no benefits; no legal work contract; workers have never heard of a Code of Conduct
Wal-Mart/Kathie Lee handbags	Ya Li Handbag, Ltd	$0.18 to $0.28	60; plus overtime up to 16-hour shifts	Forced overtime – stiff fines for refusal; overtime premium of 2½ cents an hour; some workers not paid 3-4 months; 12 to a dorm room; no benefits, no work contract; never heard of a Code of Conduct
Wal-Mart	Tianjin Yuhua Garment Factory	$0.23	60	Wal-Mart is pulling out of this factory and other publicly owned plants in the north to relocate its work to unregulated lower-wage privately owned sweatshops in the south of China
Ralph Lauren, Ellen Tracy/Linda Allard	Iris Fashions	$0.14	72-80; 12- to 15- hour shifts; 6 days a week	No union; workers paid $0.06 an hour premium for overtime; paid $0.02 for each short collar sewn
Esprit Label (Esprit Group)	You Li Fashion Factory	$0.13	93; 7:30 a.m. to midnight; 7 days a week	No overtime pay; no benefits; sometimes employees need to work 24-hour shifts; 6 to 8 people to a dorm room; dorm is dark and dirty; workers afraid; under constant surveillance; never heard of a Corporate Code of Conduct
Liz Claiborne and Bugle Boy	Shanghai Shirt 2d Factory	$0.25	66; 8 a.m. to 8 p.m.; 6 days a week	Employees fined if they don't work overtime; no union
Nike Athletic Shoes	Wellco Factory	$0.16	77-84; 11- to 12-hour shifts; 7 days a week	Workers fined if they refuse to work overtime; overtime rate not paid; most had no legal work contract; humiliation, screaming, some corporal punishment; arbitrary fining of pregnant women and older (25 years and up) women; fines if talking at work; approximately 10 children in the sewing section; most workers have never heard of Nike's Code of Conduct

Nike and Adidas Athletic Shoes	Yue Yuen Factory	$0.19	60-84	Forced overtime, no overtime premium paid; excessive noise pollution, fumes in the factory; no worker had ever heard of Nike or Adidas Corporate Code of Conduct
Adidas Garments	Tung Tat Garment Factory	$0.22	75-87.5; 12.5-hours shifts; 6 or 7 days a week	Employees fined if late/resting/found talking; forced morning callisthenics; 8 workers to a Dorm

3.3 SUMMARY

This chapter described the research problem. Combined with **Chapters 1** and **2** these provided the introduction and background to the research and completes **Phase 1.**

SECTION II – REVIEW OF EXISTING APPROACHES, DRIVERS AND INDUSTRY ACTIVITIES

Section II discusses the remaining data and results from **PHASE 1 Review of Background, Existing Approaches, Drivers and Industry Activities** of the research. The objectives to be completed in this phase were:-

- ❑ Understand the background and status relating to products and their sustainability impacts;
- ❑ Review the literature and existing approaches available and substantiate the need for a new approach for developing sustainable products and/or services:-
  - ⇒ Identify and review existing approaches relevant to developing sustainable products and/or services;
  - ⇒ Identify industry drivers and current activities relevant to developing sustainable products and/or services.

In this section, the existing approaches relevant to developing sustainable products and/or services are identified and reviewed in **Chapter 4** supplemented by **Appendices 4** and **5**. This clarifies what approaches are already in place, the need for a Triple Bottom Line focused approach for the development of sustainable products and/or services and what approaches can be built upon. Following on from this, the current industry drivers and activities relevant to developing sustainable products and services are described in **Chapter 5**. This clarifies the requirement for an approach for developing sustainable products and/or services based on industry drivers, and provides information on how industry implements existing approaches.

> *"If I have seen further it is by standing on the shoulders of giants".*
>
> Sir Isaac Newton, 1676

CHAPTER 4 : Review of Existing Approaches

4.1 INTRODUCTION

This chapter, supplemented by **Appendices 4** and **5** reviews the existing concepts, strategies, methods and tools (referred to hereafter as approaches) relevant to the development of sustainable products and/or services in industry. These were identified and reviewed to answer research question 1:-

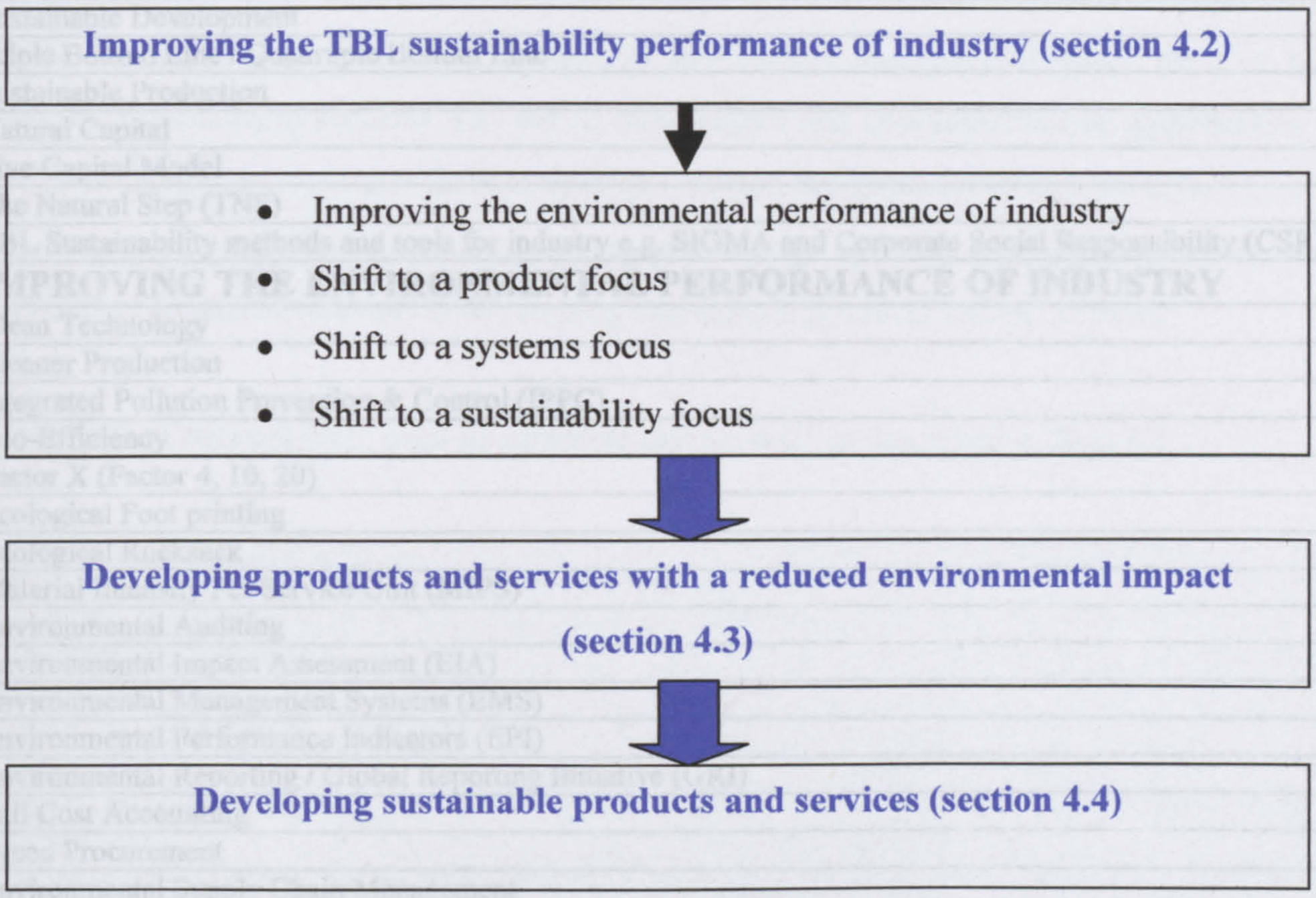
What existing approaches relevant to developing sustainable products and/or services are available to industry?

They were critically reviewed in order to achieve the following research objectives:-

- understand what existing approaches were available and used by industry relevant to the development of sustainable products and/or services;
- substantiate the need for a new approach for developing sustainable products and/or services;
- determine those existing approaches that would feed into the development of the criteria for effective SPSD implementation in Phase 2 of the research.
- determine existing approaches that would provide a basis or contribution to the development of a TBL focused SPSD approach and to be assessed in Phase 2.

Figure 4.1 illustrates how the review is structured and **Table 4.1** summarises the main approaches considered.

Figure 4.1 Review of approaches



Approaches that aim to improve the sustainability performance of industry in general, as well as those that focus on products and services specifically were investigated. These are discussed in sections **4.2 – 4. 4**. As illustrated in **Figure 4.1,** section **4.2** starts with those approaches that relate to improving sustainability performance in industry. This incorporates a diverse range of existing concepts and methods which aim to reduce the environmental impacts of industrial processes, products and services to varying degrees - one part of improving sustainability performance. This includes a shift to focus on products, as well as industrial processes, and the wider systems in which products and services operate. It also discusses the more recent concepts and methods aimed at reducing the social impacts and increasingly the Triple Bottom Line (TBL) sustainability impacts (environment, social and economic) associated with industry activities. In terms of developing sustainable products and services, a diverse range of approaches exist which focus on reducing the environmental impacts of products and are detailed in section **4.3**. Approaches focusing on reducing the more holistic sustainability impacts of products and services, are only starting to emerge and are discussed in section **4.4**.

Table 4.1 Existing approaches relevant to developing sustainable products and services

IMPROVING TBL SUSTAINABILITY PERFORMANCE OF INDUSTRY
Sustainable Development
Triple Bottom Line / Quadruple Bottom Line
Sustainable Production
Natural Capital
Five Capital Model
The Natural Step (TNS)
TBL Sustainability methods and tools for industry e.g. SIGMA and Corporate Social Responsibility (CSR)
IMPROVING THE ENVIRONMENTAL PERFORMANCE OF INDUSTRY
Clean Technology
Cleaner Production
Integrated Pollution Prevention & Control (IPPC)
Eco-Efficiency
Factor X (Factor 4, 10, 20)
Ecological Foot printing
Ecological Rucksack
Material Intensity Per Service Unit (MIPS)
Environmental Auditing
Environmental Impact Assessment (EIA)
Environmental Management Systems (EMS)
Environmental Performance Indicators (EPI)
Environmental Reporting / Global Reporting Initiative (GRI)
Full Cost Accounting
Green Procurement
Environmental Supply Chain Management
Green Marketing
Industrial Ecology
Zero Emissions
Biomimicry
DEVELOPING PRODUCTS WITH REDUCED ENVIRONMENTAL IMPACT
Environmental Product Development (EPD)
Ecodesign / Design for Environment (DfE)
Life Cycle Assessment (LCA)
Design for "X"
Product Stewardship
Extended Producer Responsibility (EPR)
Life Cycle Thinking / Life Cycle Management / Life Cycle Costing
Cradle to grave
Cradle to cradle
Total Cost of Ownership (TCO)
Product Orientated EMS (POEM)
EPD methods and tools
SHIFT TO SYSTEMS FOCUS
Sustainable Consumption and Production
Product Service Systems (PSS) / Servicising
Eco-Efficient Services
Eco-Effectiveness
DEVELOPING SUSTAINABLE PRODUCTS AND SERVICES
Sustainable Product Development (SPD) / Sustainable Product Development and Design
SPD approaches

Table 4.1 summarises the large number of approaches incorporated under each of the headings discussed in sections **4.2- 4.4** of this chapter and supplemented in **Appendices 4 and 5**. It should be noted that there is overlap between the terms listed and the divisions are not necessarily meant to be clear cut, but are presented in this way as a summary of the key approaches reviewed relevant to developing sustainable products and/or services.

Multiple data sources were used to complete this review[1] as described in **Box 4.1**.

Box 4.1 Review Data Sources

Data Sources included:-

- Literature
- Data Type 1
- Data Type 2
- Data Type 3.

Interviews with Data Type 3 (specialists representing research, policy and consultancy) focused on answering research question 1. In order to investigate this comprehensively, those approaches relevant to improving the *s*ustainability performance, and as part of this, the environmental performance, developing products with reduced environmental impact and developing sustainable products and services were incorporated. This was supplemented by one question in the email survey sent to specialists asking them to state their awareness and details of any existing guides relevant to implementing SPSD in industry. Interviews with companies obtained information on their activities relevant to developing sustainable products and/or services. All of the data from each source were critically reviewed to determine the existing approaches relevant to developing sustainable products and/or services in industry.

[1] See **Chapter 2** for a description of these data sources and collection techniques.

4.2 IMPROVING THE SUSTAINABILITY PERFORMANCE OF INDUSTRY

The concept of Sustainable Development is the current umbrella approach for moving towards a more sustainable future. Sustainable Development was first defined by the 1987 *World Commission on Environment and Development* report (the *Brundtland Report*) as:-

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

In terms of industry, proposals for how industry incorporates Sustainable Development into its approaches have been defined in a number of ways. Agenda 21 initially defined the role of business and industry in Sustainable Development as related to reducing their impact on resource use and the environment (UNED, 1992). Since then the main approaches for making industry more sustainable have focused on the environment and there are a diverse range of approaches which aim to improve the sustainability performance of industrial activities. However, the majority of these only focus on the environmental part of sustainability and aim to reduce the environmental impact of industrial activity as distinct from a Triple Bottom Line focus on social, economic and environmental considerations.

4.2.1 Improving Environmental Performance of Industry

The early approaches to reducing industry's environmental impacts focused on cleaning up specific environmental problems e.g. pollution and waste associated with production processes at industrial sites. End of pipe solutions were applied to dilute or treat these problems. A transition from the end of pipe approach came with the introduction of Cleaner Production approaches. These focused on the prevention of environmental problems, where possible, or their reduction at source in the design and operation of industrial activities. Examples include the elimination or reduction of the use of certain hazardous substances in industrial activities to prevent the generation of hazardous waste, emissions to air and water. A further characteristic of this is the consideration of environmental impacts to all media on an integrated basis to prevent moving environmental problems from one medium to another as embodied in approaches such as Integrated Pollution Prevention and Control

(IPPC) which largely prevail in Europe today (EC, 1996). In recognition of the planet's limited natural resources, concepts focused on improving resource efficiency such as eco-efficiency and Factor X have developed. Moving beyond efficient operation of industrial activities to reduce environmental impact, the Clean Technology approach questions whether the process or product is necessary to begin with in terms of human need (Clift, 1995). A short description of Eco-Efficiency, Factor X , Cleaner Production and Clean Technology are in **Box 4.2**.

Box 4.2 Eco-Efficiency, Factor X, Cleaner Production and Clean Technology

The Eco-efficiency concept promoted by the *World Business Council on Sustainable Development (WBCSD)* since 1992 is defined as:-

> *"the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity through the lifecycle, to a level at least in line with the earth's estimated carrying capacity" (UNEP and WBCSD, 1999, p. 3).*

Environmental and economic benefits in terms of cost savings are evidenced by this approach which has been increasingly practiced in industry to varying extents. In essence, eco-efficiency is about doing more with less and has its roots in early industrialisation. While the approach has both environmental and economic benefits it is increasingly seen as inadequate for long term environmental sustainability (Hanssen, 1999; Hawkens et al, 1999; McDonough and Braungart, 2002).

Leaps in resource productivity by a factor of 4 and a factor of 10 have been proposed to combat environmental degradation through more efficient usage of material and energy resources. This relates to making natural resources (e.g. energy, metals, water and forests) work four to ten times harder for the same amount of product or process. It incorporates the dematerialisation concept of reducing, or where possible eliminating, material and energy inputs (van Hemel, 1998). Factor 4 calls for a 75% reduction in materials and energy usage while Factor Ten calls for a 90% reduction. The *Factor Ten Institute, OECD, UNEP, and WBCSD* all propose that at least a Factor 10 reduction of material and energy consumption per unit of output is required in industrialised countries to reach global sustainable material and energy usage in light of increasing world population (Robèrt et al, 2002; Hawken et al, 1999). The Factor X concept provides a benchmark and metrics for the *"dematerialisation of industrialised countries needed to achieve sustainability"* (Robèrt et al, 2002, p. 208). A number of other concepts e.g. ecological "rucksack", Ecological Footprinting (Rees and Wackernagel,1994) and Material Intensity Per Service Unit (MIPS) (Schmidt-Bleek, 1997) (Service Unit being the service to be provided by an intended product and service) are additional concepts and tools for measuring and benchmarking resource productivity

(Robèrt et al, 2002).

Cleaner Production promoted by *UNEP I&E* since 1989 is defined as:-

> *"the continuous application of an integrated preventative environmental strategy to processes, products and services to increase eco-efficiency and reduce risks for humans and the environment"* (UNEP and WBCSD, 1999, p. 3).

Cleaner Production incorporates concepts such as waste minimisation, pollution prevention, energy efficiency, reuse and recycling. Cleaner Production has endorsed Factor Ten as a benchmark for sustainability in industry (Robèrt et al , 2002).

Clean Technology is formally defined as:-

> *"a means of providing a human benefit which overall, uses less resources and causes less environmental damage than alternative means with which it is economically competitive"* (Clift, 1995).

Cleaner Production has a narrower focus than Clean Technology. Cleaner Production aims to increase the efficiency of industrial processes and products in order to prevent or minimise their environmental impact. Clean Technology takes a broader view questioning whether the process or product is necessary to begin with (EPSRC, 1996).

A significant number of methods and tools exist to support these concepts and approaches in industry. These include a range of tools for the identification of environmental impact (e.g. Environmental Impact Assessment (EIA) and Environmental Auditing (with many variations)), monitoring/measurement and benchmarking of environmental impact (e.g. Environmental Performance Indicators), managing environmental impacts (e.g. Environmental Management Systems (EMS) i.e. ISO14001 and EMAS), environmental financial assessment incorporating environmental externality costs (e.g. Full Cost Accounting (FCA), Total Cost of Ownership (TCO)), green procurement, green marketing, environmental Supply Chain Management, environmental reporting (e.g. the Global Reporting Initiative (GRI)) and specific tools for a range of other activities e.g. communication and training. In addition, an increasing range of methods and tools focus on reducing the environmental impacts of products. Overall, these approaches aim to improve the environmental performance of industry in general.

4.2.2 Shift to a Product Focus

Approaches for improving the environmental performance of industry such as Cleaner Production, are applicable in theory to all activities at an industrial manufacturing facility – processes, products and services (UNEP and WBCSD, 1999). However, traditionally in practice, environmental impacts associated with the production process were the key focus of attention (European Foundation, 1997; EC, 2003; UNEP/SETAC, 2002). Current thinking is that all activities – process, products and services should be incorporated in a holistic manner in the application of environmental improvement approaches in industry (EC, 1996; UNEP, 1996; UNEP and WBCSD, 1999, EC, 2003).

This shift to focus on all activities at an industrial facility including process, products and services is a life cycle approach. The life cycle approach advocates that all lifecycle stages of an activity should be managed in a holistic and integrated way (EC, 1996; UNEP, 1996; UNEP and WBCSD, 1999, UNEP/SETAC, 2002; EC, 2003). This reflects a recognition that the environmental impacts of products throughout their lifecycle are a significant causal factor in the environmental degradation evidenced to date and that a products focus is key to achieving Sustainable Development (EC, 2001; EC, 2002; EC, 2003; DEFRA, 2002; DEFRA, 2003; UNDESA, 2002; UNDESA, 2003). As such, the focus on production processes alone in manufacturing industry is increasingly recognised as inadequate and that the focus needs to shift to incorporate all lifecycle elements of product systems that include but are not limited to the production process (UNEP/SETAC, 2002; EC, 2003; UNDESA, 2003). This is increasingly reflected in policy and legal instruments such as the EU Integrated Product Policy (IPP) (EC, 2003), EU product focused legislation e.g. the ELV (EC, 2000), WEEE (EC, 2003) and RoHS (EC, 2003a) directives and the standard *ISO /TR 14062 Integration of Environmental Aspects into Product Design and Development* (ISO, 2002a) as well as at company level. In an *Arthur D. Little* (ADL) survey of industrialists 55% of respondents to the survey voted product design as providing the most promise in achieving Sustainable Development vs. 32% for manufacturing processes (ADL, 2001). In practice, a life cycle approach is starting in industry but is not yet mainstream with many

companies still focusing on managing the environmental impacts of specific lifecycle stages, in particular production processes and end of life (European Foundation, 1997; EC, 2003; UNEP/SETAC, 2002).

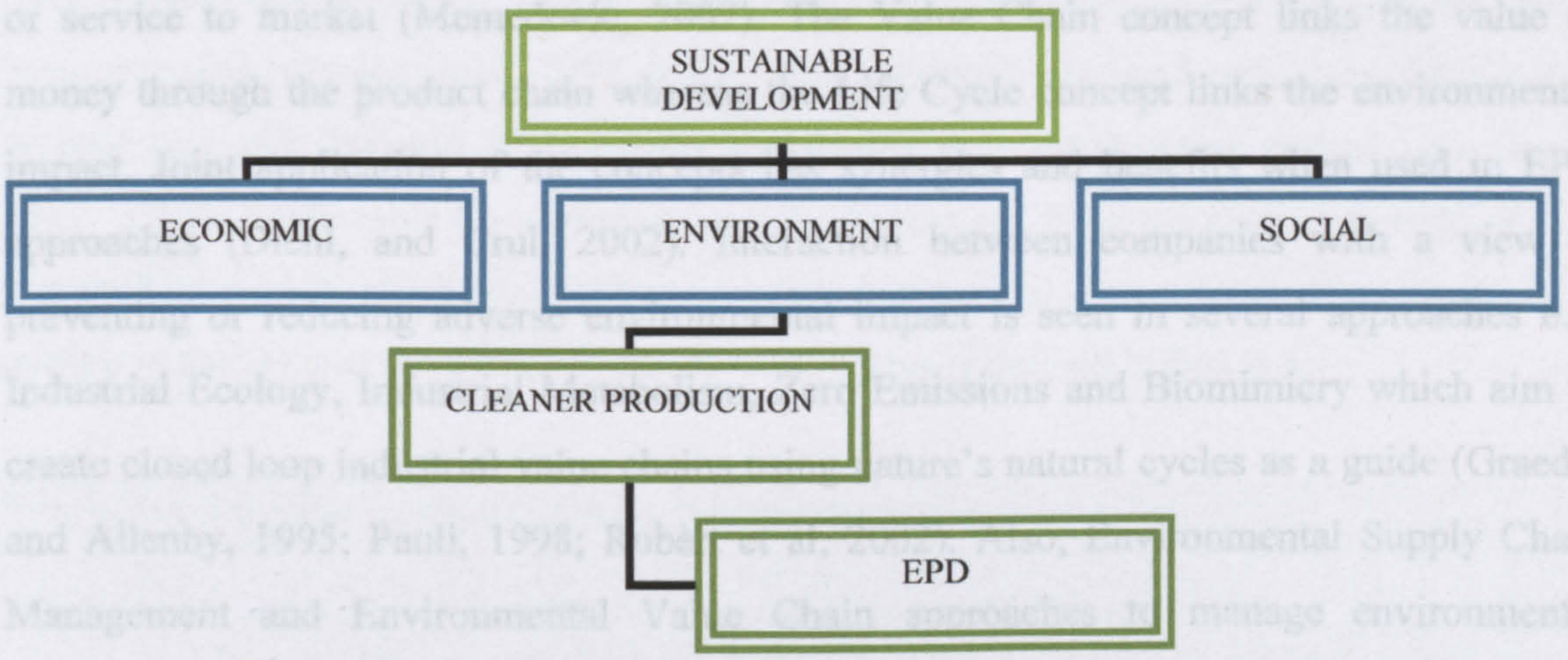
Product lifecycle stages are typically defined as raw material acquisition, production, distribution and end of life (ISO, 2002a). The terms cradle to grave (meaning a linear lifecycle from raw materials to end of life) and cradle to cradle (a cyclic closed loop lifecycle from conception to end of life and beyond incorporating reuse, recycling etc., reflect different extents of a life cycle approach (Stahel, 2001)

In industry terms, the life cycle approach represents an Extended Producer Responsibility (EPR) approach where the responsibility of the producer (i.e. manufacturer) has been extended to incorporate product life cycle stages beyond the production process with a focus on taking responsibility for product end of life. This approach is increasingly sectorally or product focused to include packaging, electronics and vehicles. This has resulted in life cycle approaches e.g. Life Cycle Thinking and Life Cycle Management receiving increasing attention (UNEP/SETAC, 2002). Life Cycle Thinking addresses environmental problems from a systems or holistic perspective with the goal of improving environmental performance over the entire lifecycle (Fava and Saur, 2002). A number of international initiatives that support the development and dissemination of industry life cycle methods and tools are in place and include the *UNEP/SETAC Life Cycle Initiative* (UNEP/SETAC, 2002), *US EPA Life Cycle Assessment* and *LC Access* programmes (US EPA, 2002) and EU ***eLCA*** project (eLCA , 2001).

This shift to focus on products has resulted in a range of concepts and tools which focus on reducing the environmental impacts of products. These are Environmental Product Development (EPD) approaches such as Ecodesign and Design for Environment (DfE) (Allenby and Fullerton, 1991; van Weenan et al, 1992; ECO2-IRN, 1995). These EPD approaches are effectively subsets of Cleaner Production and associated approaches.

Figure 4.2 highlights the relationship between Sustainable Development, Cleaner Production and EPD.

Figure 4.2 Relationship between Sustainable Development, Cleaner Production and EPD



Some Cleaner Production approaches are starting to explicitly highlight their product focus. These include Product Orientated EMS or POEMS (Meinders, 1999). This term originated at Philips to reflect their product focused EMS approach. It reflects how the main environmental impacts at a manufacturing plant can be associated with the product and hence are the key focus of the EMS. Another product focused industry initiative is Product Stewardship developed as part of the chemical industry Responsible Care Programme and aimed at considering health, safety and environmental issues from "proposal to disposal" of products (Begley, 1991).

EPD approaches generally focus on optimising the environmental impact of products over their lifecycle with key emphasis on eco-efficiency in terms of dematerialisation (reduced materials usage), de-energisation (reduced energy usage) and de-toxification (Brezet et al, 2001). The EPD approaches are detailed in **4.3.**

Another development pertaining to products and services is the interaction between companies in industry with respect to environmental issues. As products are typically produced in supply and value chains involving a number of companies who perform different functions in different locations, this is particularly relevant to EPD approaches. Value Chains are the links between companies in different global locations performing related and dependant activities (e.g. design, production and marketing) to bring a product or service to market (Memedovic, 2002). The Value Chain concept links the value or money through the product chain whereas the Life Cycle concept links the environmental impact. Joint application of the concepts has synergies and benefits when used in EPD approaches (Diehl, and Crul, 2002). Interaction between companies with a view to preventing or reducing adverse environmental impact is seen in several approaches e.g. Industrial Ecology, Industrial Metabolism, Zero Emissions and Biomimicry which aim to create closed loop industrial value chains using nature's natural cycles as a guide (Graedel and Allenby, 1995; Pauli, 1998; Robèrt et al, 2002). Also, Environmental Supply Chain Management and Environmental Value Chain approaches to manage environmental impacts across the supply and value chains are increasingly seen in industry (Croner, 2000; ESCF, 2001; Ishii and Stevels, 2000).

4.2.3 Shift to a Systems Focus

A further shift from the focus on processes and products towards a larger systems innovation approach incorporating the systems in which products operate is increasingly being advocated for sustainability (Brezet et al, 2001; van Weenan, 1997; UNDESA, 2002; Stahel, 2000; Mont, 1999; Reiskin et al, 2000). This system includes not just all product lifecycle stages but also consumption issues and a reassessment of how human needs can be met. While this is increasingly being advocated, the review revealed that little practical implementation is in place. This shift to a systems focus, reflects the view that eco-efficiency improvements to products along their entire lifecycle is not sufficient to resolve their associated environmental degradation issues (Roome, 2002; Brezet et al, 2001; van Weenan, 1997). Also, a systems focus is seen to be a key part of the policy to decouple

economic growth from resource use in order to achieve Sustainable Development (EC, 2001a; UNDESA, 2002).

Sustainable System Innovation as a means to move beyond tackling the *"environmental load of individual products"* to the *"systems context"* in which the product operates has been proposed (van den Hoed, 1997, p. 4). An example is moving beyond manufacturing greener cars and focusing on providing sustainable transport systems instead (van den Hoed, 1997). Sustainable Consumption and Production (SCP) is the current system view proposed by the UN which incorporates the entire commercial system products and services operate in and its interrelations (UNDESA, 2002). This is defined in **Box 4.3**.

Box 4.3 Sustainable Consumption and Production

Sustainable Consumption and **Production** (SCP) is defined as:-

> *"the production and use of goods and services that respond to basic human needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the lifecycle, so as not to jeopardise the needs of future generations"*(UNEP and WBCSD, 1999, p. 4)

This concept was advocated in *Agenda 21* stating that:-

> *"The major cause of the continued deterioration of the global environment is the unsustainable pattern of consumption and production, particularly in the industrialised countries"* (UNED, 1992).

The declarations from the 1992 Rio Earth Summit and Johannesburg World Summit on Sustainable Development (WSSD) both state that reduction and elimination of unsustainable patterns of production and consumption are key to Sustainable Development. A commitment to development of a ten year framework of programmes on SCP was made at WSSD (UNDESA, 2002). Development of these programmes has commenced at an international and EU level (UNDESA, 2003). As one of the first EU SCP framework approaches, the UK government defines the core of SCP as:-

> *"continuous economic and social progress that respects the limits of the Earth's ecosystems, and meets the needs and aspirations of everyone for a better quality of life, now and for future generations to come"* (DEFRA, 2003).

Obtaining significant environmental improvements through the reassessment of how human needs/functions can be provided is part of this systems shift. Consideration of whether a

functional need can be provided by an alternative to a product, such as Eco-Efficient Services (a.k.a. Eco-Services) or some combination of a Product Service System (PSS) is increasingly advocated (Stahel, 2000, Mont, 1999, Reiskin et al, 2000; Tukker, 2004). Product Service System and Eco-Efficient Services are defined in **Box 4.4** and **Box 4.5**.

Box 4.4 PSS

A **PSS** is *"a marketable set of products and services capable of jointly fulfilling a user's need. The PSS is either provided by a single company or by an alliance of companies. It can enclose products (or just one) plus additional services. It can enclose a service plus an additional product"* (Goedkoop et al, 1999)

*"The PSS concept calls for the supply of a function through a total offer, including products and services such as insurance, guarantees, maintenance and product upgrading, repair, take-back, refurbishing etc. The product chain is extended into a PSS, which includes networks of companies supporting the provision of the function"(*Mont, 2001, p. 19).

"PSS consist of a combination of eco-designed products, reinforced by designed services at different stages of a product's life cycle, and comprising different concepts of the product use, closely involving final customers and actors in the chain and beyond" (Mont, 2002, p. 241).

Box 4.5 Eco-Efficient Services

*"**Eco-efficient services** are systems of product and services, which are developed to cause a minimum environmental impact with a maximum added value"* (Brezet et al, 2001, p.8).

Examples of service elements of PSS include:-

- Products substituted by services (e.g. electronic services for physical products). This is difficult to achieve because services still require energy and material inputs (van Hemel, 1998; Mont, 2002).
- Leasing or hiring of goods rather than ownership.
- Maintenance services aimed at extending product life e.g. service, repair and upgrade.
- Revalorisation services aimed at closing the product material loop e.g. end of life take back, recovery, reuse, remanufacturing and recycling.

- Point of sale add on services to facilitate product use e.g. consumer assistance in retail stores (Mont, 2002; UNEP, 2002b).

The PSS concept shifts the corporate focus from selling products to providing functions (Mont, 2001; Engelhardt and Hammerl, 2002; Cooper and Evans, 2000). This shifts the business model from manufacture of products to meeting the functional needs of consumers or other businesses. The shift from a "product focused" to "service focused" organisation is called Servicising (Reiskin et al, 1999) or Functional Sales (Mont, 2001). This approach focuses on the operation of a functional service economy which delivers value as a continuous flow of services, e.g. where consumers lease or rent goods rather than buying them (Stahel, 2000). Moving away from individual ownership of products towards use of services is key to these service orientated concepts based on the rationale that distribution of ownership of goods has significant impacts on the volume and speed of material flow and hence has positive environmental implications. For example, taking away ownership can provide opportunities for a closed loop system in which goods at their end of life are recovered for reuse, as well as providing financial incentives for manufacturers to maximise product life (Behrendt et al, 2003).

While the sustainability pros and cons of PSS, Servicising and service economies are debated, these concepts are gaining ground. One of the key benefits seen by advocates of this approach is that it decouples volume (producing lots of products) from profitability and focuses on the functionality i.e. producing less product and managing it better as a PSS. (Reiskin et al, 2000). Research at the *Delft Sustainability Programme, US Tellus Institute, European Commission* and others indicate that in principle significant environmental improvements are possible by the provision of functions through eco-efficient services and PSS as distinct from products (Goedkoop et al, 1999; Mont, 1999; Meijkamp, 2000; Brezet et al, 2001; Reiskin et al, 1999; Behrendt et al, 2003; EC, 2003c). Examples of the environmental benefits include:-

- increased de-materialisation of product systems;

- reduced waste generation and resource usage due to the reduced volume of products produced;
- reduced waste generation and resource usage from an increase in closed loop recovery, reuse and remanufacturing as well as eco efficiencies introduced into the production process.

However, second order negative environmental effects called Rebound Effects have also been associated with this approach (Hopkinson and James, 2000; UNEP,2002b). Three levels of rebound effect are defined:-

- *"Direct Effects - where introduction of a new service creates additional demand for a closely related product or activity, e.g. energy management services reduce the cost of energy to customers who respond by having higher standards of warmth and therefore, increased energy consumption.*
- *Indirect Effects - where introduction of a new service creates additional demand for linked products or activities, e.g. scheduling services that reduce the cost of logistics and thereby stimulate demand for more transport of goods.*
- *Platform Effects - where new services influence the general factors that determine the level and patterns of production and consumption, e.g. e-learning services create better educated and richer individuals who consume and travel more than previously"* (CfSD, 2002, p. 6).

There are also potentially negative social impacts associated with PSS. For example the replacement of a product by a service can have implications in terms of employment for company personnel at many lifecycle stages.

It has also been observed that the provision of eco-efficient services may be more successful in the business to business commercial market, where it already operates to a

certain extent (e.g. car leasing, IT equipment leasing) than the consumer market (Cooper and Evans, 2000). This is due to the complexity of consumer demand and behaviour, in particular the importance of ownership. Suitability of PSS solutions to consumers on this basis is uncertain (Mont, 2001). In addition to environmental benefits, other business benefits associated with a shift towards services include new markets, potential for value creation beyond production and sales, job creation, and strengthening of local economies as demand for services generally rises (Behrendt et al, 2003).

As the eco-services and PSS concepts gain recognition, associated methods and tools are evolving. Current examples include the *PSS Development model and methodology* (Mont, 2001 (a)), PSS case examples and method (German only) (Hammerl, 2003; Hammerl, 2004; Service Innovation, 2004) and the *Eco-Efficient Services Methodology* (Brezet et al, 2001). The EU *SusProNet* research project to identify state of the art in PSS and create a network of PSS practitioners (due to complete at the end of 2004) illustrates the increased awareness of PSS as a concept in Europe (SusProNet, 2003). A number of PSS tools are also currently being developed to include:-

- Methodology PSS (MEPSS) toolkit – due for completion end 2004 (van Halen and Karsch, 2001; van Halen, 2004)
- Prosecco (Fornasiero, 2004)
- Method for Implementing PSS for Consumer Products developed under the EU *ELIMA* (Environmental Life-Cycle Information Management and Acquisition for consumer products) project (ELIMA, 2003; Yang et al, 2004).

A shift from eco-efficiency to environmental effectiveness has also been advocated as part of this systems approach and necessary for global sustainability (Hanssen, 1999; McDonough and Braungart, 2002). Environmental effectiveness is *"a measure first to reduce or modify the need for a certain function and then finding the most efficient solution to fulfil the function" (Hanssen, 1999, p. 15).*

4.2.4 Shift to a Sustainability Focus

A further evolution in improving the sustainability performance of industry is to incorporate not just environmental protection but also social and ethical equity in conjunction with traditional business and economic considerations. This is Triple Bottom Line (TBL) sustainability. Some definitions of TBL sustainability for business and industry are provided in **Box 4.6**.

Box 4.6 TBL Sustainability

"Sustainability is the principle of ensuring that our actions today do not limit the range of economic social and environmental options open to future generations" (Elkington, 1997, p. 20). This is known as the *"Triple Bottom Line"* (TBL) in business as distinct from the traditional *"financial bottom line"* (Elkington, 1997). TBL provides a translation of Sustainable Development into a business context and focuses *"on economic prosperity, environmental quality and – the element which business has tended to overlook – social justice"* (Elkington, 1997, p. 20). The term Quadruple Bottom Line incorporating economic, environmental, social and ethical performance is also used. TBL sustainability is the current mainstream concept for defining sustainability in business and industry.

"Sustainable Development is one approach to meeting stakeholder expectations and developing long term prosperity. In essence companies taking a sustainable development approach to business are integrating their pursuit of three inter-connected goals: economic growth, environmental excellence and social responsibility" (ADL, 2001, p. 1).

"Sustainable Development is a dynamic process which enables all people to realise their potential and improve their quality of life in ways which simultaneously protect and enhance the Earth's life support systems" (Forum for the Future, 2002, p. 1)

Approaches which aim to achieve more holistic TBL sustainability in industrial activities are fewer in number than environmental improvement approaches, very recent and still evolving. These include Corporate Social Responsibility (CSR) (or Corporate Responsibility (CR)) and Sustainable Production. Both these concepts are defined in **Box 4.7** and **4.8**.

Box 4.7 CSR

CSR is a *"concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis"* from EU Green Paper on CSR (EC, 2001b p. 10). An ISO standard for CSR is under consideration (ISO Bulletin, 2002). CSR aims to provide a concept, method and toolbox for achieving Sustainable Development in industry (BITC, 2003)

Box 4.8 Sustainable Production

Sustainable Production is the *"creation of goods and services using processes and systems that are non polluting; conserving of energy and natural resources; economically efficient; safe and healthful for employees, communities, and consumers; socially and creatively rewarding for all working people"*. A set of principles for Sustainable Production provides a *"conceptual framework for the design of production in the context of the ecological systems of the planet and the organization of work in the context of the social systems of the community, the nation, and the world"* (Kriebel et al, 1998, 18).

The Sustainable Product Development (SPD) concept encompasses TBL sustainability criteria in the development of products, services and systems for the provision of human need (van Weenan, 1997; Hanssen, 1997). SPD methods and tools are detailed in section **4.4.**

A number of concepts and approaches take a more holistic systems approach to sustainability. These include The Natural Step and Natural Capitalism. These have particular application to industry as well as to wider systems. A brief description of each is included in **Box 4.9** and **4.10.**

Box 4.9 The Natural Step

The Natural Step (TNS) is an approach to Sustainable Development and is gaining acceptance in several countries and organisation types (to include industry) as an effective method for Sustainable Development (Robèrt, 1991). TNS encompasses a move from linear to cyclic cycles and defines a strategic method for social and environmental sustainability based on four system conditions. In a sustainable society nature is not subject to:-

1. Increasing concentrations of substances from the lithosphere;
2. Increasing concentrations of substances produced by society;
3. Degradation by physical means, and
4. Resources must be used efficiently and fairly to meet basic human needs worldwide (Robèrt et al, 2002).

TNS provides a method to systematically replace activities that are not compatible with the system conditions with activities that are or can be moved in that direction. Upstream thinking and backcasting (the starting point of planning is the envisioned successful future outcome from which the strategic routes for achieving this are defined) are used in the process of seeking a substitute (Waage, 2003).

Box 4.10 Natural Capitalism

Natural Capitalism defines an approach to connect human institutions (including industry) within the flow of natural cycles (Hawkens et al, 1999). This proposes that "our global commons", to include long term global quality of life for people and wellbeing of ecosystems, is incorporated into global economic models and provides a framework for this integration. This framework proposes the economy as a subset of the global environment, limiting future economic growth in line with natural capital (all natural resources) rather then human made capital, full valuation of all forms of capital in market systems, a shift to focus on delivery of services to meet human needs as distinct from goods, radical resource productivity increases and reinvestment in sustaining and expanding natural capital (Hawkens et al , 1999).

Forum for the Future has developed the *Five Capitals Model* which defines five types of capital assets which must be managed for sustainable business. These are:-

- Natural capital (the environment);
- Human capital (people);
- Social capital (social relationships and structures);

- Manufactured capital (fixed assets);
- Financial capital (e.g. profit and loss, sales, shares and cash) (Forum for the Future, 2002).

Sustainable Innovation is the current concept being discussed and researched for Sustainable Development. According to the UK *Sustainable Technologies Programme* Sustainable Innovation is seen as innovation whose aim is to generate benefits that are collective in terms of the environment, society and economy (STP, 2003) and reflects a new "out of the box" approach, that challenges traditional systems (Charter and Kajzer, 2002). According to *ADL's* report "Realising the Business Value of Sustainable Development", "*innovation is the key platform for corporate success*" (ADL, 2001, p. 3).

In terms of the social dimension of sustainability, a small number of approaches which aim to reduce the social impacts of industrial activities have been developed. These include frameworks and standards that provide a specification for identifying and managing social impacts e.g. *AA1000* Series for accountability and stakeholder engagement (AccountAbility, 2002) and *SA8000* (SAI, 2002) aimed at certifying labour practices in companies, their subsidiaries, suppliers and vendors.

Sustainability management frameworks for business are starting to emerge such as those being developed by the UK *Project SIGMA - Sustainability Integrated Guidelines for Management*[2]. A set of principles to guide decisions on sustainability, a management framework and a toolbox to support the management framework have been developed (SIGMA, 2003). Its application is for all company activities – process, products and services and it is based on the TNS and Five Capital Model approaches.

> *"The SIGMA principles consist of 2 core elements – holistic management of five different types of capital that reflect an organisation's overall impact and wealth (in the broadest sense) and accountability to society through transparency and responsibility for the management of the capitals framework"* (SIGMA, 2003).

[2] Project involving *Forum for the Future*, *British Standards Institution* and *AccountAbility*, and the UK *Department of Trade and Industry* as well as a number of pioneering companies.

The five capital types are the same as the *Forum for the Future's Five Capitals Model* discussed above. The five capital types are intended to reflect an "inter-related nature" between the different elements of Sustainable Development rather than *"false trade offs between social, economic and environmental factors"* (SIGMA, 2003 p. 19). The SIGMA principles see the TBL and five capital types as complementary with manufactured and financial capital representing the economic bottom line, natural equating to environmental and human and social capital representing social (SIGMA, 2003).

The SIGMA Management Framework can be integrated with existing approaches (e.g. ISO 14001, EMAS, ISO 9000, AA1000 and TNS) or used as a standalone sustainability framework. There are a range of associated tools aimed at improving aspects of business sustainability performance e.g. a benchmark questionnaire, a process for stakeholder dialogue and a sustainability scorecard. In addition to SIGMA, *BSI* is also starting development on a Sustainability Standard (Watson, 2003).

Support tools for TBL sustainability are growing. At present these include methods and tools that provide a framework for sustainability, measuring, benchmarking and sustainability reporting. Examples of these tools are in **Table 4.2**.

Table 4.2 Examples of TBL Sustainability methods and tools

Sigma Project sustainability guidelines (SIGMA, 2003)
Social Venture Network Standards of CSR (Goodell, 1999)
Business in the Community (BITC) guidance for corporate community investment, CSR/CR and the BITC Corporate Responsibility Index (BITC, 2003)
Dow Jones Sustainability Index defines indicators to assess a companies' sustainability (DJSI, 2003)
Ethical Trading Institute has a base code for ethical trade based on International Labour Organisation's conventions (ETI, 2003)
UN Global Compact for corporate citizenship in the world economy (Global Compact, 2002)
The *Caux Round Table (CRT)* comprised of business leaders from Europe, Japan and North America has a *Principles for Business* to include social, ethical and environmental criteria among others (Caux Institute, 2003)
Global Reporting Initiative provides a number of guidelines to help companies become sustainable (GRI, 2003)
Global Sullivan Principles of social responsibility

International Chamber of Commerce guidelines for responsible business conduct (ICC, 2003)
MHC International model to measure CSR (MHC, 2002)
OECD Guidelines for multi-national enterprises aims to enhance their sustainable development (OECD, 2003)
Sustainable Development Indicators produced by an US Government inter-agency team (SDI, 2003)
United Nations Environment Programme produces annual reports on benchmarking the sustainability of corporations
World Business Council for Sustainable Development matrix of CSR indicators (WBCSD, 2003)
Sustainable Project Appraisal Routine (SPEAR) – developed by *Arup Environmental* assesses the sustainability of company activities in terms of environmental, economic, social and natural resources criteria (Wilks, 2000).
Chemical Industry Association (CIA) under its *Responsible Care* programme is currently developing a set of Sustainable Development performance goals with an initial set of Safety, Health and Environmental goals released in January 2003 (CIA, 2003).
Institute of Chemical Engineers Sustainability Metrics with environmental, social and economic indicators to measure sustainability performance (IChem E, 2002).

This concludes section **4.2**. The approaches outlined in this section aim to different extents to make industrial activities more sustainable and focus on all industrial activities to include process, products and services. Building on this section, this review now moves on to present a discussion of the approaches associated specifically with improving the sustainability performance of products and services. First, the significant volume of approaches aimed at reducing the environmental impact of products are discussed in **4.3.** Second, the more recent and emerging concepts, methods and tools relevant to incorporating TBL sustainability in the development of products and services are discussed in **4.4.**

4.3 DEVELOPING PRODUCTS AND SERVICES WITH REDUCED ENVIRONMENTAL IMPACT

A significant range of concepts, methods and tools have been developed to identify and reduce the environmental burden of products (Croner, 2000; Charter,1999; Simon et al, 1998; Byggeth et al, 2000 and Byggeth & Broman, 2000). These are Environmental Product Development (EPD) approaches most commonly known as Ecodesign or Design for Environment (DfE) (Allenby and Fullerton, 1991; van Weenan et al, 1992; ECO2-IRN, 1995; Brezet and van Hemel, 1997)[3]. There are also a series of approaches known as Design for "X", some of which are focused on specific lifecycle stages such as end of life e.g. Design for Disassembly and Design for Recycling (van Hemel and Keldmann, 1996). These approaches can be considered as subsets of ecodesign. A description of ecodesign is in **Box 4.11**.

Box 4.11 Ecodesign

Ecodesign *"considers environmental aspects at all stages of the product development process, striving for products which make the lowest possible environmental impact throughout the product lifecycle"* (Brezet and van Hemel, 1997 p. 37).

Four levels of ecodesign activities which incrementally improve the eco-efficiency have been described (Brezet et al, 1996; ECOLIFE, 2002). This reflects the historical development of EPD approaches moving from Design for X to a more holistic systems based approach.

The four levels of ecodesign are:-

Level 1: Incremental product improvement (from the perspective of pollution prevention)
Level 2: Product redesign (product concept remains the same but parts are replaced or improved to reduce environmental impact)
Level 3: Function Innovation (new product concept definition – an innovation change by alternative fulfilment of functionality)
Level 4: System Innovation (changes in related infrastructure and organisation in order to develop products and services on a system level (Brezet et al, 1996; ECOLIFE, 2002).

[3] Other terms include Environmentally Conscious Design (ECD), Life Cycle Design (LCD), Environmentally Conscious Design and Manufacture (ECDM), and Environmental Adapted Product Development (EAPD) (Alting, 1993; Ryding, 1995; ECO2-IRN, 1995).

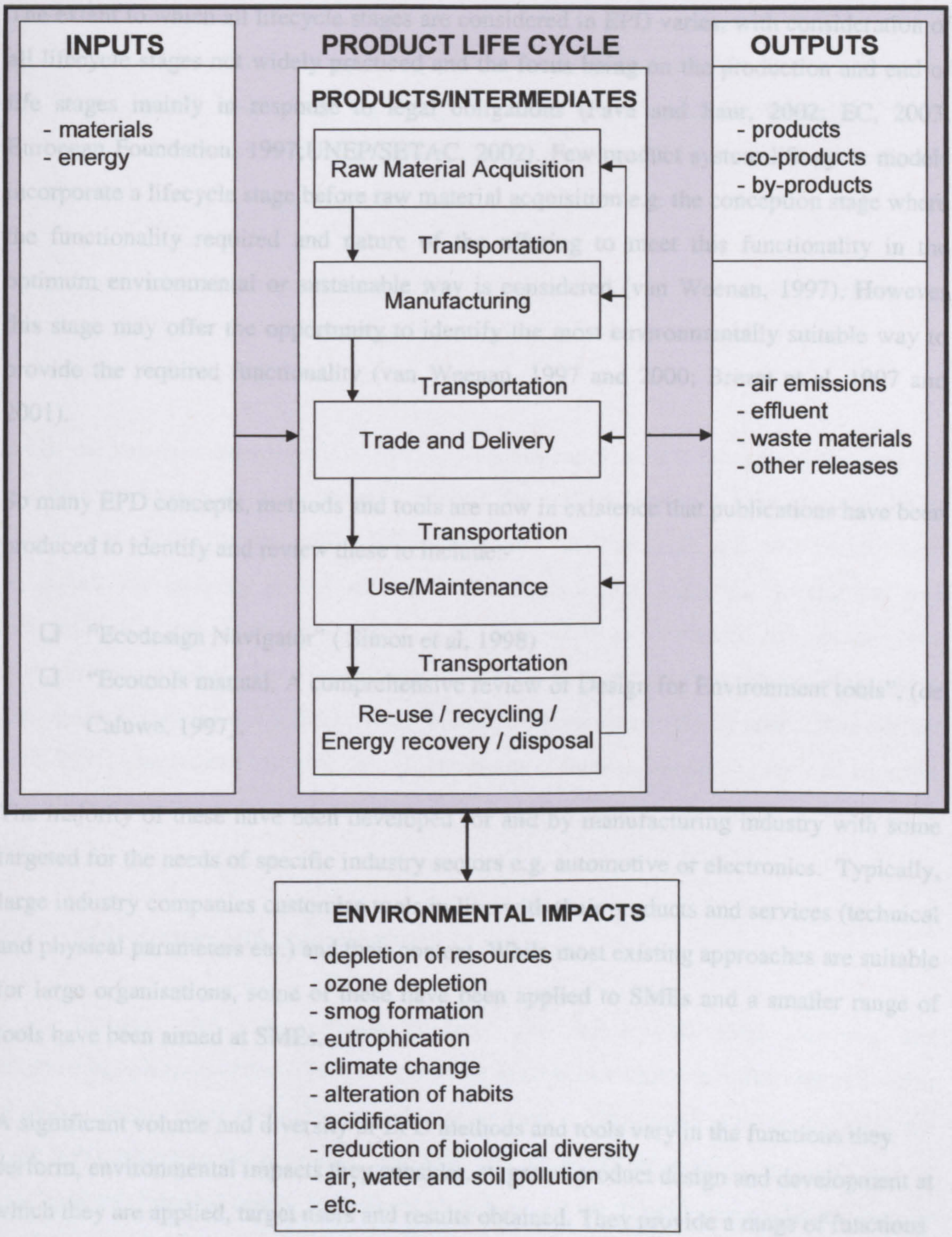
In terms of ecodesign status, levels 1 and 2 are well addressed with potential for levels 3 and 4 still to be exploited (Stevels, 2000). Levels 3 and 4 are increasingly being recognised as key for sustainable products and services (Brezet et al, 2001; van Weenan, 1997; Stahel, 2000; Mont, 1999; Reiskin et al, 2000)

While a number of terms have evolved for the overall approach of reducing the environmental impact of products, they all focus on identifying and optimising the environmental impacts of a product either at specific lifecycle stages such as end of life or throughout its life cycle. For simplicity the term **EPD** will be used to describe all these approaches for optimising the environmental performance of products.

In terms of their development, early EPD approaches have an emphasis on the product end of life driven mainly by legal compliance related waste prevention and disposal motives (van Weenan, 1997; Fava and Saur, 2002; EC, 2003; UNEP/SETAC, 2002). These approaches include Design for Pollution Prevention, Design for Longevity, Design for Remanufacturing, Design for Recycling, Design for Reuse, Design for Disassembly (OECD, 1982; Henstock, 1988; Cooper, 1994; European Foundation, 1997; Stahel, 1997). Specific approaches are motivated by the requirement to eliminate or reduce specified hazardous substances e.g. in chemicals or electronics. Such approaches include the EU Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS) Directive (EC, 2003). More evolved approaches focus on all product life cycle stages using Life Cycle Thinking (UNEP/SETAC, 2002). Typically the product life cycle stages are defined as five steps from raw material acquisition to end of life (i.e. cradle to grave). These five lifecycle stages as defined in *ISO/TR14062* (ISO, 2002a) as well as the inputs, outputs and examples of environmental impacts are illustrated in **Figure 4.3**[4].

[4] See **Chapter 5** and **Appendix 4** for more information on *ISO14062*.

Figure 4.3 Product life cycle stages, Inputs, Outputs and Environmental Impacts as illustrated in ISO/TR14062 (Source: reproduced from ISO/TR14062, 2002, Figure 1, p. 8)



The extent to which all lifecycle stages are considered in EPD varies, with consideration of all lifecycle stages not widely practiced and the focus being on the production and end of life stages mainly in response to legal obligations (Fava and Saur, 2002; EC, 2003; European Foundation, 1997;UNEP/SETAC, 2002). Few product system life cycle models incorporate a lifecycle stage before raw material acquisition e.g. the conception stage where the functionality required and nature of the offering to meet this functionality in the optimum environmental or sustainable way is considered (van Weenan, 1997). However this stage may offer the opportunity to identify the most environmentally suitable way to provide the required functionality (van Weenan, 1997 and 2000; Brezet et al, 1997 and 2001).

So many EPD concepts, methods and tools are now in existence that publications have been produced to identify and review these to include:-

- "Ecodesign Navigator" (Simon et al, 1998)
- "Ecotools manual, A comprehensive review of Design for Environment tools", (de Caluwe, 1997).

The majority of these have been developed for and by manufacturing industry with some targeted for the needs of specific industry sectors e.g. automotive or electronics. Typically, large industry companies customise tools in line with their products and services (technical and physical parameters etc.) and their context. While most existing approaches are suitable for large organisations, some of these have been applied to SMEs and a smaller range of tools have been aimed at SMEs.

A significant volume and diversity of EPD methods and tools vary in the functions they perform, environmental impacts they consider, stages of product design and development at which they are applied, target users and results obtained. They provide a range of functions to include:-

- EPD strategy and implementation;
- Assessment and decision support e.g. Life Cycle Assessment (LCA);
- "Topic specific" assessment e.g. Design for Reuse or Design for Disassembly;
- Integration with business and economic factors e.g. accounting, supply chain or quality systems.

There is some overlap between these categorisations and they are only used to facilitate the description of the range of EPD methods and tools. Each of these categories are summarised in **4.3.1 – 4.3.4** below.

While the environmental benefit of EPD approaches are clear, it is recognised that they are insufficient to reach the improvement required for true sustainability (van Weenan, 1997; Brezet et al , 2001, Roome, 2002). While there are a lot of methods and tools which " *help to polish the existing frame of basically unsustainable industrial production and consumption*", van Weenan suggests that we need to "*redesign the frame...with sustainability in mind*" (Euro Foundation, 1997). There is growing recognition of a need to distinguish between ecodesign and more broadly focused sustainability approaches (Brezet et al, 2001; Charter and Tischner, 2001). The status of these sustainability focused concepts and approaches for developing products and services based on the review is presented in **4.4.**

4.3.1 EPD strategy and implementation

These methods and tools provide guidance for industry on EPD strategies and implementation approaches. These are umbrella approaches which may encompass a range of tools. Overall, these methods and tools can be used to identify the potential for EPD, the main EPD strategies for a product and facilitate implementation in product and service development. Detailed design assessment tools e.g. Life Cycle Assessment (LCA)[5] may be used as part of this implementation as suitable. Dependant on the requirement, one or a

[5] See also section **4.3.4.**

number of tools may be used on an integrated basis. Strategy tools are largely qualitative with the remainder of the tools e.g. LCA quantitative. These methods and tools are ideally used when designing a new product, but can be applied retrospectively to existing products. The methods use a Life Cycle approach focusing on optimising environmental impact over the product lifecycle which is generally taken to include the typical five stages. The methods incorporate existing product development approaches e.g. Concurrent Engineering and implementation issues e.g. management, organisation, communication, training, supply chain, green marketing and financial assessment to varying extents. The methods are largely in book, guidance manual, checklist forms and, for a few, in software and web based forms. Some examples are listed in **Table 4.3**.

Table 4.3 Examples: EPD Strategy and Implementation Methods and Tools
Design for Environment: Creating Eco-efficient Products and Processes, USA (Fiksel, 1996)
Ecodesign: A Promising Approach to Sustainable Production & Consumption (known as the "PROMISE Manual"), The Netherlands (Brezet and van Hemel , 1997)
Life Cycle Design (LCD) Manual for SMEs and Checklist, EU (Behrendt et al, 1997)
Philips Electronics Point of No Return Ecodesign Guidelines (Philips, 1997) and Greening Your Business (Philips, 2000)
Ecodesign Navigator, UK (Simon et al, 1998)
Method for Sustainable Industrial Product Systems, Norway (Hanssen, 1997)
RMIT EcoReDesign™ Guide and Video, Australia (Gertzakis et al, 1997)
Environmental Assessment of Products. Volume 1: Methodology, Tools, and Case Studies in Product Development (Wenzel et al, 2000)
Design + Environment: A Global Guide to Designing Greener Goods (Lewis, 2001)
Product Innovation – The Green Advantage. An Introduction to Design for Environment for Austrialian Business (Environment Australia, 2001)
How to do EcoDesign? A Guide for Environmentally and Economically Sound Design, Germany (Tischner et al, 2000)
Life Cycle Design Guidance Manual, (US EPA, 1993)
Design for Environment Guide (web based) (National Research Council of Canada, 2002)
Design for Environment (Canadian Standards Association, 2001)
Module de sensibilisation à L'Éco-conception (web based), France (ADEME, 2001)
Ecodesign A training guide for business including Idea! Integrated Design Abacus, UK (Owen, 2001)

Green Concurrent Engineering: A Model for DfE Management Program, Sweden (Karlsson, 2001)
Integration of environmental aspects in product development based on LCA, Denmark (Nielsen and Wenzel, 2002)
ISO Guide 64 for the Inclusion of Environmental Aspects in Product Standards (ISO, 1997)
ISO /TR 14062 Integration of Environmental Aspects into Product Design and Development (ISO, 2002a)
Design of Eco-Efficient Services, The Netherlands (Brezet et al, 2001)
Eco Design Guide: Environmentally Improved Product Design Case Studies of the European Electrical and Electronics Industry, EU (ECOLIFE, 2002)
Ecodesign - the Electrical and Electronic Practical Eco-design Guide, Spain (Rodrigo and Castells, 2002)
IVF Handbook for environmentally compatible electronic products IVF, Sweden
Centre for Sustainable Design (CfSD) Eco-Design Checklists, UK (Clark and Charter, 1999)
Standard ECMA - 341, "Environmental design considerations for electronic products", (ECMA International, 2002).
A Designer's Guide to Eco-Conscious Design of Electrical and Electronic Equipment - web based guide supported by the Danish EPA (GN- Teknik, 2002)
Environmentally orientated product design: A guide for companies in the electrical and electronics industry, Finland(Kärnä, 2001)
Implementing Design for Environment, a primer guide (Ehrenfeld, 1997) developed by Digital Equipment and MIT.

Examples of a selection of these tools are summarised in **Appendix 4.**

4.3.2 Assessment and decision support

This section outlines EPD tools in addition to those outlined in **4.3.1** which play a role in the assessment and environmental improvement of a product and service during EPD. These focus mainly on the identification of environmental impact and the options for eliminating or reducing environmental impact. This includes a range of tools aimed at functions such as data collection, assessment/analysis, measurement / benchmarking. Further decision support tools to facilitate prioritisation and communication of environmental improvement options are included. These tools are often a subset of the EPD Strategy and Implementation methods or can be used on a standalone basis dependant on the situation. The main tool under this category is Life Cycle Assessment outlined in

4.3.2.1 below. Some examples of other assessment and decision support tools are in **Table 4.4**.

Table 4.4 Assessment and Decision Support Tools
MET Matrix to quickly assess products (Brezet and van Hemel, 1997) or META (Materials, Energy, Toxic Substances, Added Value) Matrix used for services (Bijma, 1999)
Cumulative Energy Demand (CED) Matrix focusing on energy demand and Material Input per service unit (MIPS) Analysis focusing on material and energy input
ESW diagrams e.g. the Life Cycle Design Strategies (LiDS) Wheel (Brezet and van Hemel, 1997)
Eco-compass developed in conjunction with Dow Chemical (Fussler , 1996)
Ecodesign Matrix provides a framework for prioritising product environmental improvement options in terms of environmental, business, customer, technical and financial benefits (Stevels, 2000)
Product Improvement Matrix developed at AT&T and used to assess environmental impact throughout the product lifecycle in terms of materials choice, energy use, solid, liquid and gaseous residues (Graedel, 1996)
E PASs Method for assessment and benchmarking developed by Delft University to generate product environmental improvement options (Jansen, 1998)
Environmental Benchmark (EBM) approach developed and used at Philips (Philips, 2000)
Ecoquest developed by Delft University, is a web based self audit tool for electronics industry suppliers providing a quick assessment of supplier products and services to identify potential environmental improvements (Brink et al, 2000)
SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats) and Philips Fast Five used at Philips (Philips, 2000)
Ecodesign Tool expert system developed at Manchester Metropolitan University in collaboration with Nortel Technology Ltd. (Poyner and Simon, 1996)
Green Design Advisor (GdA) software for EPD analysis and reporting used by Motorola
EIME Software for environmental evaluation of electronic goods (ECOLIFE, 2002)
STRETCH Strategic Environmental Challenge developed by Philips provides a framework for identifying a product and service environmental improvement strategy in brainstorming sessions (Stevels, 2000)
EDEN Eco Profiler software tool for data management and environmental improvement option profiling (Benjamin , 1997)
EcoCosts Value Ration (EVR) to enable the environmental gain of different options to be estimated (Vogtländer et al, 2000)
LEADS-II – an expert system evaluation tool for EPD options (Rombouts, 2000)
A range of databases of environmentally preferable materials have been and are developing to provide environmental information for materials selection. These include

Euromat and Ecotox. Euromat is a software based method and database for the EPD process focusing on materials selection and has been used at Ford Motor Company (ECOLIFE, 2002).

The following legal compliance obligations can also fit into this category:-

- Provisions in the Annexes of the ELV (for automotive manufacturers) (EC, 2000), WEEE (EC, 2003) and RoHS (EC, 2003a) (for electronics manufacturers) Directives regarding legal compliance issues on topics such as materials exclusion, selection, recovery and recycling.
- Provisions in the Annexes of the draft Ecodesign of End Use Equipment directive (EC, 2003d) for ecodesign activities.

Tools can be used to facilitate creativity and idea generation at the assessment stage e.g. Vision in Product Development (ViP) (Brezet et al, 2001) and Progressive Abstraction (Tischner, 2001).

4.3.2.1 Life Cycle Assessment (LCA)/Life Cycle Inventory(LCI)

Life Cycle Assessment (LCA) (Lindfors et al, 1995) is a core method for assessing the environmental impacts of products over their lifecycle. ISO published standards "*ISO 14040 – 4* and *48 – Life Cycle Assessment*" provide a specification for LCA (ISO, 1998; ISO, 1999; ISO, 2000; ISO 2000a, ISO, 2002) with ISO14047 and ISO14049 providing LCA examples (ISO, 2003; ISO, 2000). The majority of EPD tools are for LCA. This research has identified over eighty LCA/LCI tools currently available for use in industry. In general, these tools are designed to conduct LCA to different extents. These include:-

- Compiling a comprehensive, quantified inventory of all environmental impacts (LCI) ;
- Compiling an inventory and evaluating this to determine the best ways to reduce the environmental impacts (LCA). The extent to which this is done defines the tool as full LCA, abridged LCA or LCA based (Todd , 1996).

The overall aim of LCA is to identify, assess and quantify the environmental impacts of products and processes. The impacts can be calculated in terms of their contribution to national, regional and global environmental issues e.g. contribution to global warming, damage to the ozone layer etc. The majority of these tools are software based and are linked to a database of environmental data to enable the impacts to be quantified and calculated. Databases of several of the European packages are increasingly available, however specific, customised data should ideally be input into the database to give accurate results. Some of the tools have been customised on an industry basis e.g. the electronics (ECOPACK2001) and packaging sectors (Repaq). Generally, LCA tools are data intensive and require a significant time commitment from the user. The end results are quantified impacts, the accuracy of which is only as good as the information in the database. Examples of LCI, LCA and abridged LCA tools are in **Appendix 4**.

4.3.3 Topic Specific Assessment Tools

In general, topic specific tools focus on the following areas:-

- Design for disassembly, reuse, remanufacturing and recycling;
- Waste and Pollution Prevention.

The design for disassembly, reuse etc. are a range of design aid tools used to identify and analyse product end of life options for disassembly, reuse, remanufacturing and recycling. Collectively they are known as "Design for X" tools. Some examples are in **Table 4.5.**

Table 4.5 Examples: "Design for X" tools
Boothroyd-Dewhurst-TNO Software packages: Design for Assembly, Design for Manufacture, Design for Service and Design for Environment
LASeR (Life Cycle Assembly Serviceability and Recycling prototype program)
GE Plastics Design for Recycling Manual
CfSD Design for Recycling checklist
End of Life Design Advisor (ELDA)
Assessment tool for Recycling Orientated Design ATROiD® 3.0

The *Boothroyd-Dewhurst-TNO* "Design for Environment" packages are one example of these tools. These evaluate product design regarding disassembly and end of life disposal options and associated costs in order to identify the best options environmentally and economically. The End of Life Design Advisor (ELDA) developed at *Stanford University* is used to develop product end of life strategies during product design (Stevels and Rose, 2000). Some Design for X activities are sectorally focused e.g. the Design for Active Disassembly using SMART Materials (ADSM) programme at *Brunel University* focusing on developing SMART materials for the electronics and automotive sectors to facilitate end of life disassembly (ADSM, 2001).

The waste & pollution prevention are a series of tools used to incorporate waste and pollution prevention into the product design process. This is most developed in the USA. Examples are in **Table 4.6**.

Table 4.6 Examples: Waste & Pollution Prevention tools
P2-EDGE –software identifying opportunities for pollution prevention in the design process
SWAMI (Strategic Waste Minimisation Initiative) – software to identify & prioritise opportunities for waste minisation and the cost in the design process

4.3.4 Integration with other Business Factors

As EPD is part of the product development process, tools for assessing the impact of environmental changes in conjunction with other assessment criteria, business and economic factors are used. These include tools relating to quality, technical feasibility, communications, supply chain management, financial assessment, risk assessment and stakeholder interaction. Some examples of these tools used as part of the EPD process include those listed in **Table 4.7**. It should be noted that a selection of EPD strategy and implementation methods incorporate the integration of environment with other business criteria from an early stage and hence this is part of the method used. Other methods use existing business tools and add in environment either on an integrated or stand alone basis.

Table 4.7 Tools integrating environment with other assessment criteria
House of Environmental Quality uses a multidimensional matrix approach to assess how product characteristics impact each other
Quality Function Deployment (QfD)
Failure Mode and Effects Analysis (FMEA) and Environmental (E) FMEA
Eco-design and SCM – a guide for incorporating SCM into ecodesign (Charter and Clark, 1999)
Environmental cost accounting methods to determine a cost benefit analysis for different environmental improvement options incorporating all life cycle issues to incorporate all costs and internalise externality environmental costs e.g. end of life recovery , reuse or disposal
Life Cycle Costing (LCC)
Total Cost Accounting
Full Cost Accounting
Total Cost of Ownership (TCO)
Environmental Value Chain Analysis (EVCA)

As an example, EVCA, developed between *Delft* and *Stanford* universities and used at *Philips Consumer Electronics,* aims to:-

> *" identify pertinent customer and other stakeholder' interests, their value perceptions and the relationship between these parties in green product or process development projects" (Ishii and Stevels, 2000, p. 3).*

The approach includes:-

- an assessment of the values between the mainstream product and service chain (suppliers, producers, providers and customers) and their stakeholders;
- an assessment of the value chain internal to an organisation;
- use of an internal Issue Correlation Matrix to reflect these interactions (Ishii and Stevels, 2000).

4.4 DEVELOPING SUSTAINABLE PRODUCTS AND SERVICES

The need for an approach to product and service development which responds to essential human needs, includes TBL aspects and fits a sustainable future has been highlighted (van Weenen, 1997; Charter and Tischner, 2001; Bygeth and Broman, 2002; Simonsson and Barthel, 2002). Research in the area of sustainable product and service development is growing and some early concepts, strategies and techniques are now starting to evolve for industry (Holmberg et al, 2000). **Box 4.12** states the UNEP sustainable products and services definition.

Box 4.12 UNEP definition of sustainable products and services

"Sustainable products and services are solutions that realise critical energy and material resource savings. They are context sensitive, future orientated and designed to fulfil elementary human needs in an equitable and environmentally harmonious way'. Sustainable products and services effectively change consumption and production patterns by substantially reducing the overall usage of materials and energy in industrialised countries. They counteract the adoption of unsustainable production and consumption lifestyles in un-industrialised countries by providing functional and cost effective alternatives to meet needs." (UNEP WG SPD, 2000).

UNEP note that this definition for sustainable products and services is closely linked to the concept of Factor 4, 10 and 20 as described in **Box 4.2**.

Sustainable Product Development (SPD) is the current term/concept for the design and development of sustainable products and services. SPD is the process of making product systems more sustainable throughout their lifecycle (Hanssen, 1997; van Weenen, 2000; Byggeth et al, 2000; Charter and Tischner, 2001). There are a number of definitions and variations on this term. Some definitions follow in **Box 4.13** and **4.14**.

Box 4.13 Sustainable Product Development

*"**Sustainable Product Development (SPD)** can be defined as resource, context and future oriented product development, aimed at providing elementary needs, a better quality of life, equity and environmental harmony"* (van Weenan, 1997, p. 14).

Box 4.14 Sustainable Product Development and Design

*"**Sustainable Product Development and Design (SPDD)** is concerned with 'balancing economic, environmental and social aspects in the creation of products and services. SPDD looks to minimise adverse sustainability impacts and maximise sustainable value throughout the life cycle of the product, building or service. To create sustainable products and services that increase stakeholders quality of life, while at the same time achieving major reductions in resource and energy use....."* (Charter, 1998).

The SPD approach stresses equity and the importance of developing countries in terms of global sustainability. In light of globalisation and the global nature of product supply and value chains, this aspect of SPD is highly relevant.

The SPD and SPDD approach are distinct from the EPD approaches e.g. ecodesign and DfE, in that they go beyond the environmental optimisation of products and consider the whole concept of sustainability (European Foundation, 1997; Simon and Sweatman, 1997; Frei, 1998; Byggeth et al, 2000; Tischner and Charter, 2001; Simonsson and Barthel, 2002). Ecodesign aims to reduce environmental impact at each stage of the product lifecycle. In practice, this is done to varying extents and incorporating some or all of the lifecycle stages (Tischner and Charter, 2001, van Weenan, 2000). Early approaches focused on end of life and later approaches incorporate earlier stages (van Weenan, 1997; European Foundation, 1997; Fava and Saur, 2002; UNEP/SETAC, 2002;EC, 2003). Very few products emerging from ecodesign are products of systematic ecodesign dealing with all lifecycle stages (van Weenan, 1997; EC, 2003) and few consider the most sustainable way to provide functional needs which is a key aspect of SPD (van Weenan,1997). The SPD concept incorporates a number of transitions when compared to traditional EPD approaches e.g. ecodesign (van der Hoed, 1997). These are illustrated in **Table 4.8**.

Table 4.8 Transition from EPD to SPD

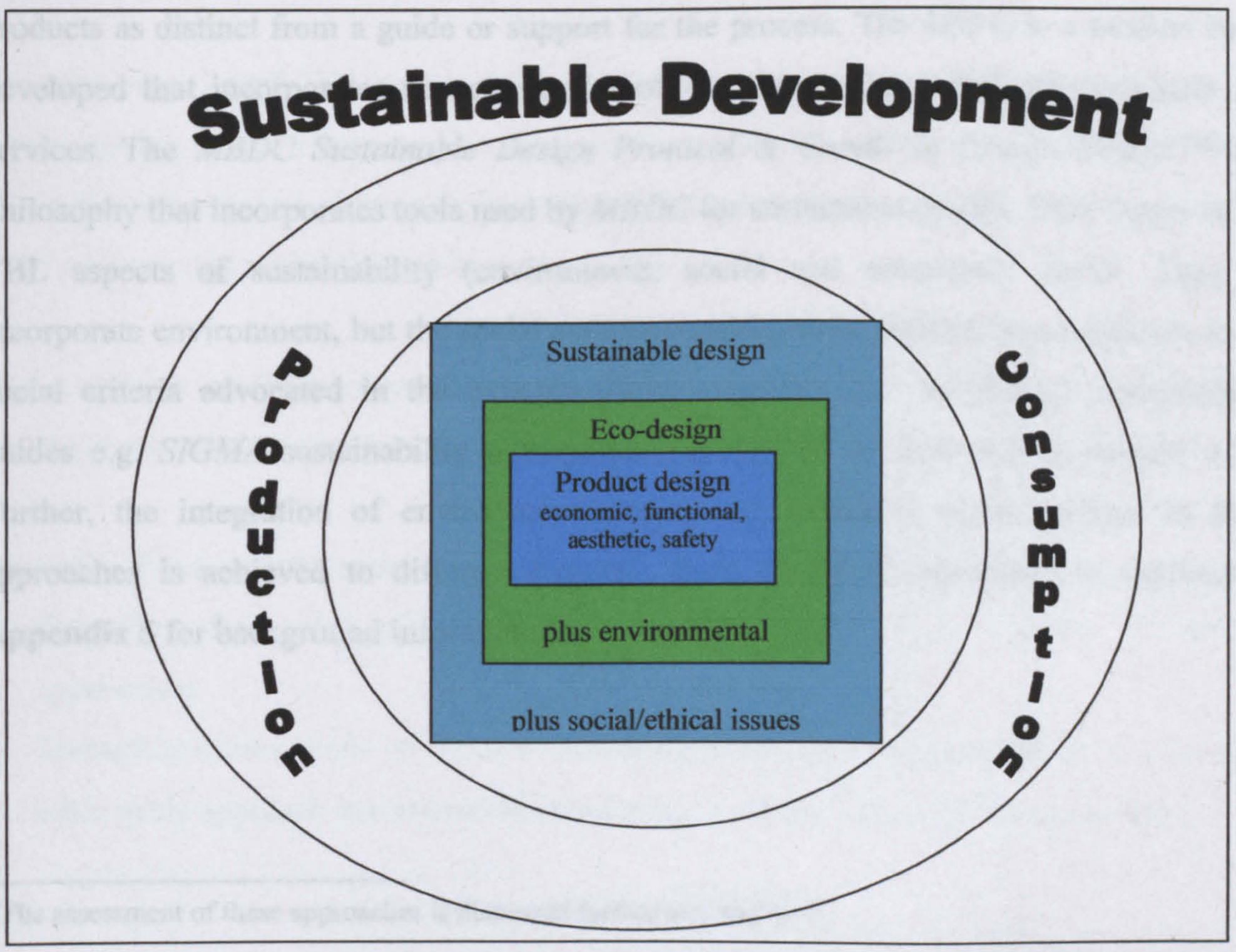
EPD	**TO**	**SPD**
From product optimisation	to	product innovation
From product level	to	system level
From product design process	to	innovation process

EPD approaches can be seen as subsets of SPD which focus only on the environmental dimension of sustainability (Charter and Tischner, 2001).

> *"SPD is more than ecodesign, as it integrates social and ethical aspects of the product's life-cycle alongside environmental and economic considerations – aiming for the so-called "triple bottom line" "*(Charter and Tischner, 2001 , p. 121).

SPD and eco-design are seen as key components of sustainable development relating to production and consumption. **Figure 4.4** illustrates this relationship. From the centre of the figure, product design which deals with the traditional product criteria e.g. functionality, economics, safety and aesthetics is illustrated. In the next layer, ecodesign adds in "environment" as a criterion to product design. SPD at the next layer adds in "social and ethical" issues to product design criteria. Overall, EPD and SPD are part of Sustainable Development as it relates to production and consumption. This is the relationship between SD, SPD and EPD.

Figure 4.4 Relationship between SD, SPD and EPD, (Source: reproduced from Tischner, 2000)



While the SPD concept exists, SPD in practice is at a very early stage. Supports aimed at reducing the more holistic adverse sustainability impacts that incorporate not just environmental impacts but also social and economic impacts are only starting to be considered (Byggeth and Broman, 2000; Charter and Tischner, 2001; Simonsson and Barthel, 2002). Approaches that incorporate social as well as environmental criteria in the development of products and services include:-

- *Method for Sustainable Product Development (MSPD)* (Byggeth et al, 2000; Byggeth & Broman , 2000);
- *Cyclic/Solar/Safe* (Datschefski, 2001);
- *McDonough Braungart Design Chemistry (MBDC) Sustainable Design Protocol & Cradle to Cradle Design*™ (McDonough and Braungart, 2002).

These approaches provide concepts and strategies relevant to developing sustainable products and services. *Cyclic/Solar/Safe* is a philosophy for developing more sustainable products as distinct from a guide or support for the process. The *MSPD* is a method being developed that incorporates concepts and tools for developing sustainable products and services. The *MBDC Sustainable Design Protocol & Cradle to Cradle Design*™ is a philosophy that incorporates tools used by *MBDC* for sustainable design. Their focus on the TBL aspects of sustainability (environment, social and economic) varies. They all incorporate environment, but the social aspects considered are limited in comparison to the social criteria advocated in the existing social standards e.g. *AA1000* or sustainability guides e.g. *SIGMA* sustainability management guidelines as discussed in section **4.2.4**. Further, the integration of environment, social and economic considerations in these approaches is achieved to different extents[6]. Each of these approaches is outlined in **Appendix 5** for background information.

[6] The assessment of these approaches is discussed further in **Chapter 7**.

The review also identified that *TNO* and *Price Waterhouse Coopers* expect to release shortly a new tool called *Innovation Scan Product Services* (in Dutch) incorporating TBL criteria regarding the development of sustainable PSS (Tukker, 2003; van Halen, 2004), but this was not available for review at the time of the research. The *MEPSS* PSS method is also to include a TBL focus and is expected to be available by the end of 2004 (van Halen, 2004). Further, *The Natural Step* are researching incorporating sustainability into product design and explicitly including social aspects (Waage et al, 2003; TNS, 2003).

4.5 DISCUSSION

This chapter reviewed the existing approaches relevant to developing sustainable products and services. The critical review of the existing approaches has provided an understanding of what existing approaches are available and used by industry relevant to the process of developing sustainable products and/or services in a true TBL context. These approaches included those focusing on:-

- improving overall TBL sustainability performance of business and industry in general;
- improving the environmental performance of processes, products and services;
- improving the TBL sustainability performance of processes, products and services and the systems in which they exist.

The evolution of these approaches towards TBL sustainability and how this relates to developing sustainable products and services can be summarised by the following stages:-

- Initial focus on environmental dimension of sustainability only;
- Transition from end of pipe to preventative solutions by Cleaner Production approaches;
- Transition from a focus on process orientated environmental management to a focus on a life cycle approach incorporating process and product such as EPD approaches;

- Transition to a systems focus incorporating the systems in which products and services interact and requiring innovation;
- Re-evaluation of the provision of functional human needs through services and PSS combinations as distinct from provision of physical products alone;
- Transition from linear cradle to grave life cycle approaches to closed loop cradle to cradle lifecycle approaches based on natural systems;
- Transition to a TBL sustainability approach integrating environmental protection, social equity and economic prosperity in the provision of functional needs such as SPD approaches.

The practical implementation of these approaches in industry are at different stages of the evolution outlined above, with many companies focused on the environmental dimension of sustainability and using a diverse range of environmental improvement methods and tools. A smaller number of more innovative companies and typically large MNC are incorporating TBL sustainability approaches aimed at improving the sustainability performance of their activities in general (ADL, 2001; SustainAbility, 2001; ENDS, 2002). In terms of the development of products and services, some innovative companies practice EPD approaches with a very small number focusing on the more holistic SPD approach (Byggeth and Broman, 2000; Charter and Tischner, 2001; Simonsson and Barthel, 2002). Detail on industry activities in these areas is provided in **Chapter 5.**

The review identified a significant volume and range of EPD approaches (Simon et al, 1998; Croner, 2000; Charter ,1999; Byggeth et al, 2000 and Byggeth & Broman, 2000). These tend to focus on optimising the eco-efficiency of products and in a few cases product and service systems over a range of lifecycle stages, in particular with respect to three main strategies:-

- Dematerialisation;
- De – energergization (e.g. de-carbonization);
- De-toxification (Brezet et al, 2001).

It was revealed that few approaches go beyond optimising the environmental impact of products and the incorporation of broader TBL sustainability issues such as social impacts and integration with wider business issues. SPD concepts exist, with industry methods and tools aimed at reduction of the more holistic adverse sustainability impacts at an early stage (Byggeth and Broman, 2000; Charter and Tischner, 2001; Simonsson and Barthel, 2002). SPD approaches incorporating not just environmental but also social criteria are starting to develop e.g. *MSPD* (Byggeth et al, 2000; Byggeth & Broman, 2000) and *MBDC Sustainable Design Protocol & Cradle to Cradle Design*™ (McDonough and Braungart, 2000). Also, the *MEPSS* PSS method currently in development includes a TBL focus (van Halen. and Karsch, 2001; van Halen, 2004). These incorporate social criteria to different extents, but not yet to the extent advocated in the growing guidance on social and sustainability criteria as discussed in section **4.2.4**. While SPD approaches are starting to develop, no TBL focused mainstream approach that supports the process of developing sustainable products and/or services was found to be currently available to industry. This substantiates the need for a new approach for developing sustainable products and/or services. The many approaches reviewed would provide a basis for the development of a TBL focused SPSD approach. In particular, a sample of those identified which provide a support for the implementation process relevant to developing sustainable products and/or services were selected for detailed assessment in **Phase 2** of the research, and are listed in **Table 4.9**[7]. The assessment of these methods was part of **Phase 2** of the research and is described in **Chapter 7**.

[7] Further information on all of these methods and approaches is in **Appendices 4** and **5.**

Table 4.9 Implementation Methods/Approaches Chosen for Detailed Assessment

IMPLEMENTATION METHODS/APPROACHES
Ecodesign: A Promising Approach to Sustainable Production & Consumption (known as the "PROMISE Manual"), The Netherlands (Brezet and van Hemel , 1997)
Life Cycle Design (LCD) Manual for SMEs and Checklist, EU (Behrendt et al, 1997)
Philips Electronics Point of No Return Ecodesign Guidelines (Philips, 1997) and Greening Your Business (Philips, 2000b)
Ecodesign Navigator, UK (Simon et al, 1998)
Method for Sustainable Industrial Product Systems, Norway (Hanssen, 1997)
RMIT EcoReDesign™ Guide and Video, Australia (Gertzakis et al, 1997)
Environmental Assessment of Products. Volume 1: Methodology, Tools, and Case Studies in Product Development (Wenzel et al, 2000)
Design + Environment: A Global Guide to Designing Greener Goods (Lewis, 2001)
How to do EcoDesign? A Guide for Environmentally and Economically Sound Design, Germany (Tischner et al, 2000)
US EPA Life Cycle Design Guidance Manual (US EPA, 1993)
Design for Environment Web Guide (web based) (National Research Council of Canada, 2002)
Ecodesign A training guide for business including Idea! Integrated Design Abacus, UK (Owen, 2001)
ISO /TR 14062 Integration of Environmental Aspects into Product Design and Development (ISO, 2002a)
Design of Eco-Efficient Services, The Netherlands (Brezet et al, 2001)
Eco Design Guide: Environmentally Improved Product Design Case Studies of the European Electrical and Electronics Industry, EU (ECOLIFE, 2002)
Ecodesign - the Electrical and Electronic Practical Eco-design Guide, Spain (Rodrigo and Castells, 2002)
Centre for Sustainable Design CfSD Eco-Design Checklists, UK (Clark and Charter, 1999)
Standard ECMA - 341, "Environmental design considerations for electronic products", ECMA International (2002)
A Designer's Guide to Eco-Conscious Design of Electrical and Electronic Equipment - web based guide supported by the Danish EPA (GN- Teknik, 2002)
Environmentally orientated product design: A guide for companies in the electrical and electronics industry, Finland (Kärnä, 2001)
McDonough Braungart Sustainable Design Protocol & Cradle to Cradle Design™ (MBDC) (McDonough and Braungart, 2002)
Method for Sustainable Product Development (MSPD) (Byggeth et al, 2000; Byggeth & Broman , 2000)

4.6. SUMMARY

This chapter reviewed the existing approaches relevant to developing sustainable products and/or services. The results were used, *inter alia*, in the development of the criteria for effective SPSD implementation[8] and in the new SPSD approach[9] in **Phase 2** of the research. To complete **Phase 1**, the industry drivers and activities relevant to developing sustainable products and services were analysed. This is discussed next in **Chapter 5.**

[8] Discussed in **chapter 6.**
[9] Discussed in **chapter 8.**

"From bigger is better to smarter is better."
Caterman, CEO, ABB

CHAPTER 5: INDUSTRY DRIVERS AND ACTIVITIES IN DEVELOPING SUSTAINABLE PRODUCTS AND SERVICES

5.1 INTRODUCTION

This chapter describes the current industry drivers and activities relating to the development of sustainable products and services. These were identified and critically reviewed in order to answer research questions 3 and 4:-

What are the drivers for manufacturing industry to produce more sustainable products and/or services?

How does manufacturing industry implement approaches relevant to developing sustainable products and/or services?

In addition to the review of existing approaches discussed in **Chapter 4**, critically assessing the industry drivers and activities relating to the development of sustainable products and services contributed to the research objectives. Information on the industry drivers, activities and how industry implements existing approaches fed into the development of the criteria for effective SPSD implementation and the new SPSD approach in **Phase 2** of the research.

The information on the industry drivers and current activities incorporated in this chapter originate from a range of data sources[1] as summarised in **Box 5.1** below. All of the data from each source were critically reviewed to determine the industry drivers and activities

[1] See **Chapter 2** for a description of these data sources and collection techniques.

relevant to developing sustainable products and/or services. The results of this review are presented in this chapter.

Box 5.1 Data Sources

- Literature
- Data Type 1
- Data Type 2
- Data Type 3
- Data Type 4.

Data Type 4 (companies participating in the ESP initiative) were only used to determine industry drivers. A list of the Data Type 1-4 sources and contact personnel is in **Appendix 2**. The information was gathered mainly using literature review, interviews and email survey questionnaire. Templates for the interview questionnaire used for companies and the email survey questionnaire are in **Appendix 3.**

Environmental policy, legislation and standards are shifting to focus more on products, creating increasing drivers for industry to develop products with reduced environmental impact. The legal and market drivers are detailed in section **5.2**. Largely in response to these drivers, industry activities relevant to developing sustainable products and services (mainly as Environmental Product Development (EPD)) are increasing. The industry activities are reviewed in sections **5.3 - 5.5**

5.2 INDUSTRY DRIVERS

Industry activity relating to the development of more sustainable products and services is motivated largely by increasing policy, legal and market pressures to reduce the environmental impact of products as well as more general sustainable development policies (Croner, 2000; Shapiro and White, 1997; van Hemel and Cramer, 2002). This has resulted in activity in eco-design in recent years. In particular, key motivators are the ongoing environmental policy and legal shift towards products and a life cycle approach with Extended Producer Responsibility (EPR) for manufacturers. In the EU, this is resulting in

direct legal compliance drivers for specified industry sectors and their products e.g. packaging, vehicles and electronics goods.

5.2.1 Environmental policy, legislation and voluntary instruments focusing on products

This section outlines the shift towards products and a life cycle approach which is emerging in environmental policy, legislation and voluntary instruments. These illustrate that a range of instruments are already in place and being developed which focus on reducing specific environmental impacts of products. A summary of examples of EU policy, legislation and voluntary initiatives which focus on reducing the environmental impacts of products is included[2].

EU and international environmental policies and legislation are increasingly focusing on measures to reduce the environmental impacts of products. At the bigger picture level, international policies and programmes are starting to be developed to accelerate a shift towards Sustainable Consumption and Production (SCP) to focus on the production of sustainable products and services (the supply side), the generation of consumer markets for these (the demand side) and its interrelations (UNDESA, 2002; DEFRA, 2003; EC, 2003e). In Japan their SCP approach is focusing on developing a "recycling economy" and in China the approach is called a "circular economy" with initiatives in both countries aiming towards a closed loop approach incorporating the recovery of products for reuse and recycling (de Leeuw, 2004).

At the product level specifically, environmental policy and legislation in a number of countries, to include the EU and Japan, has started to focus on the product development process with a view to reducing its environmental impacts. In particular, the European

[2] There are a range of EU environmental policies and law which indirectly can be associated with environmental improvements in products e.g. the Landfill Directive (EC, 1999) preventing certain products being disposed of to landfill, but only examples of those directly focusing on reducing the environmental impact of products are included.

Commission and UNEP have acknowledged that focusing on reducing the environmental impacts of industrial production processes alone is not sufficient to achieve the improvements in environmental quality required (EC, 1999; EC, 2000; Aloisi de Larderel, 2001; UNEP WG SPD, 2000). Because the life cycle of products, in particular their consumption and end of life issues, can cause such significant environmental degradation, the EU is now focusing on policy and regulatory developments to reduce these environmental impacts (EC, 2001). The EU 6th Environmental Action Programme "*Environment 2010: Our Future, Our Choice*[3] (EC, 2001a), highlights product policy as a key element of environmental policy and a number of policy and legislative instruments focused on reducing the environmental impact of products have been implemented or are currently being developed. These include the following which are outlined in **Box 5.2**:-

- Integrated Product Policy (IPP) (EC, 2001c; EC, 2003)
- Council Directive 94/62/EC on Packaging and Packaging Waste (EC, 1994)
- Council Directive 2000/53/EC on End-of Life Vehicles (ELV) (EC, 2000a)
- Council Directive on 2002/96/EC Waste from Electrical and Electronic Equipment (WEEE) (EC, 2003a) and Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) (EC (2003 b)
- Proposal for a directive establishing a framework for the setting of Eco-design requirements for Energy-Using Products (EUP) and amending Council Directive 92/42/EEC (EC, 2003d).

Box 5.2 Examples of EU policy and legislation focused on reducing the environmental impact of products

IPP

IPP is the proposed EU framework policy for reducing the environmental impact caused by products. A *Green Paper on IPP* (EC, 2001c) was produced in 2001 and a *Communication* (EC, 2003) has been adopted by the European Commission in June 2003.

IPP aims at continuous improvement in the environmental performance of products throughout their life-cycle using Life Cycle Thinking, however the main focus is on the production, use and disposal phases. Initiatives to facilitate product disassembly, reuse and recycling at end of life are advocated under this framework policy. The IPP approach

[3] The 10-year vision for European environmental policy.

focuses on EPR whereby the producer's (i.e. product manufacturer's) responsibility is extended from environmental impacts generated at the production facility to those associated with other phases of the product life cycle, and in particular product use and disposal phases. The IPP approach is to be designed to make the producer responsible for product take back at end of life, reuse, recycling, disposal and treatment. These are seen as motivational factors which force the producer to eliminate or minimise environmental impacts when designing the product, thereby minimising the impacts to be dealt with at end of life. Each of the legislative instruments below is an example of EPR legislation.

The provision of products, services or PSS are within the scope of IPP. The 2003 Communication states that the IPP focus will be on products to begin with as more information is available on products as distinct from services.

The Communication outlines the IPP strategy which includes a number of actions to be taken to stimulate environmental performance improvement in products. These include making existing tools (e.g. EMS) more product focused, developing best practice guides, identifying those products with the greatest potential for environmental improvement, running green product pilot projects and adopting a Commission green procurement programme. Flexible implementation measures to include legislation, taxation and voluntary measures are seen as potentials for implementation. Diverse stakeholder engagement to include industry, retailers, consumers and policy makers is seen as important to implementing the IPP strategy (EC, 2003).

Council Directive 94/62/EC on Packaging and Packaging Waste (EC, 1994)

This legislation is now well established in the EU and aims to reduce the environmental impact of packaging mainly through maximizing the recovery of used packaging and eliminating hazardous materials in packaging.

Council Directive 2000/53/EC on End-of Life Vehicles (ELV) (EC, 2000a)

The aim of this legislation is to prevent, where possible, and minimise waste from vehicles. EPD concepts are advocated in the design of vehicles to minimise environmental impacts at source, and to facilitate disassembly, recovery, reuse and recycling for ELVs. There is a focus on eliminating or minimising hazardous substances e.g. lead, mercury, cadmium and hexavalent chromium in vehicles, with bans specified for set time limits. Facilities are to be set up for collection, recovery and treatment of ELV. The producer is responsible for the associated costs.

Council Directive on 2002/96/EC Waste from Electrical and Electronic Equipment (WEEE) and Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

The WEEE (EC, 2003a) and RoHS (EC, 2003b) Directives aim to reduce the environmental impact of electronics goods by the removal of specified hazardous

substances in manufactured equipment (RoHS) and the management of electrical and electronic waste (WEEE). The legislation has significant implications for all electronics manufacturers as well as the electronics waste recovery/recycling sectors. The categories of electronics equipment covered in the EU legislation include:

- Large and small household appliances
- IT & telecommunication equipment
- Consumer equipment
- Lighting equipment
- Electronic and electrical tools
- Toys
- Medical equipment systems (with the exception of implanted and infected products)
- Monitoring and control instruments
- Automatic dispensers

Key requirements under the legislation are:-

- The introduction of a take back scheme for WEEE;
- National recovery & recycling targets for WEEE throughout the EU;
- Banning the use of specified hazardous substances (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and Polybrominated Diphenyl Ethers (PBDE) in electronics products, and
- Electronics equipment producers to design and manufacture electrical goods to facilitate WEEE recovery, disassembly, reuse and recycling.

EPD activities e.g. ecodesign are advocated to reduce waste at source through improved product design. From August 2005, electronics producers are to be responsible (to include financially) for the collection, treatment, recovery and disposal of waste electronics goods.

Proposal for a directive establishing a framework for the setting of Eco-design requirements for Energy-Using Products (EUP) and amending Council Directive 92/42/EEC (EC, 2003d)

The aims of the proposed directive are as follows:-

- To improve the environmental performance of EuP by encouraging manufacturers to use ecodesign in the design and development of products. There is a focus on making products more energy efficient and hence contributing to the security of energy supply;
- To ensure the free movement of energy using products based on a coherent EU wide framework designed to prevent market barriers.

This is proposed as a framework directive and would enact implementing measures on specific products, environmental aspects and ecodesign requirements. The implementing measures could apply to any product using energy to perform its function. The intention is that this broad brush approach will result in quicker environmental performance

improvements especially regarding energy efficiency. Criteria for selecting products include:-

- energy using products sold in high volumes in the EU;
- having significant environmental impact;
- presenting significant potential for improving environmental performance without entailing excessive costs;
- community environmental priorities.

The directive is applicable to product components as well as finished products and is to exclude vehicles as they are considered covered by other instruments. Products with high CO_2 reduction potential are likely to be focused on. These are identified as products in the following equipment sectors (in order of the highest reduction potential):-

- Electric motor systems;
- Office equipment in both domestic and tertiary sectors;
- Lighting in both domestic and tertiary sectors;
- Consumer electronics;
- Heating and water heating equipment;
- Domestic appliances;
- Commercial HVAC (heating ventilation air conditioning) systems.

The ecodesign approach is to assess the main environmental impacts of the product throughout the product lifecycle and implement strategies to eliminate or minimise these and improve the environmental performance of the product. Particular environment aspects focused on are energy consumption, emission of pollutants to all media (e.g. emissions of greenhouse gases, acidifying and ozone depleting substances), use of natural resources, use of hazardous materials, increasing end of life reuse and recycling. Conformity will be implemented using the existing CE conformity marking scheme. Before placement onto the market the manufacturer will be required to declare that the ecodesign provisions have to be met subject to certain exclusions.

Other EU policy initiatives currently in development, relevant to aspects of reducing the environmental impact of products are:-

- Environmental Technology Action Plan (EC, 2004a) – one on the technologies promoted under this plan is the development of less polluting and resource intensive products and services.
- Thematic strategy on Waste Prevention and Recycling (completion expected April 2005) (EC, 2003f)

- Thematic strategy for the sustainable use of natural resources (completion expected April 2005) (EC, 2003g)
- Developing thematic strategy on Urban Environment (EC, 2004b) – this proposes to focus on the provision of more sustainable physical infrastructure to include sustainable transport and construction
- Proposed REACH legislation and system for chemicals (EC, 2003h; EC, 2001e).

There is also EU legislation aimed at providing consumer information on the environmental impacts of products. Some examples include:-

- Council Directive 92/75/EEC on the indication by labeling and standard product information of the consumption of energy and other resources by household appliances (EC, 1992) resulting in the *EU Energy Label* seen on white goods.
- Directive 1999/94/EC on labeling of new cars to show their CO_2 emissions and fuel efficiency (EC, 1999a).

5.2.1.1 Voluntary Initiatives: Labels and Standards

On the voluntary side, EU legislation enabling producers to voluntarily register their product or service for an EU Eco-Label is in place. The original 1992 legislation regarding the EU Eco-label was revised in 2000 as *Regulation (EC) No 1980/2000 on Eco-labeling of Products (*EC, 2000b). Under this, specifications for the environmentally conscious design and development of twenty-one categories of products covering twelve major manufacturing areas (e.g. computers, furniture, textiles, detergents, paper, paints, varnishes and soil improvers) and one service (tourism) are currently in place, with new categories being regularly added (EU Ecolabel, 2004). If offerings meet these specifications, their producers can apply for and maintain an EU Eco-label accreditation. There are currently several hundred EU Eco Labeled products (with the largest proportion from the product groups textiles, paints and varnishes, and a respectable showing from detergents, soil improvers and tissue paper) and four tourism services (EU Ecolabel, 2004).

One aim of this legislation is to increase the market for 'green' products, by allowing compliant firms to use the label to brand and market their products in order to demonstrate their environmental commitment and performance. Other market based labeling schemes also in place include the *Nordic Swan* (range of products and services), *Energy Star* (office equipment), *EU Energy Label* (white goods: refrigerators, washing machines and dryers), *VOC paint label*, *Organic* (food), *Fair Trade,* and *Forest Stewardship Council* (timber products). Example logos are illustrated in **Figure 5. 1**.

Figure 5.1 Examples of Eco Label Logos

EU Eco Label



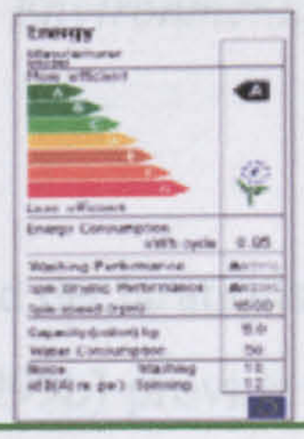
Energy Star



Forest Stewardship Council



Energy Label



Eco-labels consider the environmental impact in one or all stages of the life cycle of the product. There are several labeling schemes that cover the environmental impact and energy consumption of electrical equipment. These include:-

- *Energy Label*
- *Energy Star*
- *German Blue Angel*
- *Swiss Energy 2000*
- *Nordic White Swan*
- *EU Eco label for computers*
- *Swedish TCO ' 99*
- *Canadian Environmental Choice Eco label.*

The *Nordic Swan* eco label has also recently been extended to services. This label is a measure of the overall eco-efficiency of the product or service concerned over its lifecycle. Services such as hotels and retailers are now covered under this label (Nordic ecolabeling, 2002; ENDS, 2002a). Proposals for common labels on an EU and international level for the key products causing climate change to reflect carbon efficiency have been proposed by the *UK Advisory Committee on Products and the Environment*, with no implementation to date (DEFRA, 2002).

In terms of the use of environmental labels and declarations, *ISO14020- 21 –Environmental labels and declarations* (ISO, 1998b; ISO, 1999b) provide a specification for use. In order to prevent misleading green claims for products and services, the EU are considering an approach for green claims which may become mandatory under the EU directive on misleading advertising. The UK launched the *Green Claims Code* in 1998 with an update in 2000 (DETR, 2000). Meant as supplementary guidance to ISO14021, this Code requires environmental labeling to be clear, accurate, capable of being supported by scientific evidence, relevant to the particular product or service and significant in terms of the overall impact of the product on the environment during its lifecycle (DETR, 2000).

Social labeling is less evident with labels e.g. FSC focusing on environmental and social issues and Fair Trade aiming to link low income producers with international markets.

Looking at standards, the *ISO* has published standards relating to reducing the environmental impact of products. These include:-

- *ISO Guide 64 - Guide for the inclusion of environmental aspects in product standards* (ISO, 1997)
- *ISO 14040 – 44* and *48 – Life Cycle Assessment* (ISO, 1998; ISO, 1999; ISO, 2000; ISO 2000a, ISO, 2002)
- *ISO14047* and *ISO14049*, LCA examples (ISO, 2003; ISO, 2000)
- *ISO14020- 21 –Environmental labels and declarations* (ISO,1998 (b); ISO,1999(b))
- *ISO /TR 14062 Integration of Environmental Aspects into Product Design and Development* (ISO, 2002a)

In addition, as part of the revision of the EMS standard *ISO14001* (ISO, 1996), more information on a life cycle approach which focuses on managing the environmental impacts of both production processes and products is to be incorporated in the EMS specification (Lee, 2000).

Some industry specific product standards for environmentally conscious design have also been developed. These mainly exist for the automotive, packaging, electronics/ ICT sectors. Some examples include:-

- *ECMA – 341, Environmental design considerations for electronic products* (ECMA International, 2002);
- *ECMA-328 Detection and measurement of chemical emissions from electronic equipment* (ECMA International, 2001);
- *EN/BSI 13428:2000 Packaging – Requirements specific to manufacturing and composition – Prevention by source* (BSI, 2000)

5.2.2 Market Drivers

The policy and legal drivers are translated further into market drivers especially through the supply chain as ensuring compliance between B2B customers becomes necessary for retaining business. An example of this is an electronics Original Equipment Manufacturer (OEM) requiring their relevant supply chain companies to ensure their raw material(s) or product component(s) to be in compliance with the WEEE and RoHS directives. This supply chain pressure is particularly relevant as a driver for SME business from their larger customers (Byggeth et al, 2000; Byggeth and Broman, 2000; van Hemel and Cramer, 2002; Maxwell and van der Vorst, 2003). Competition to develop technologies in line with WEEE or RoHS compliance is resulting in the market setting standards in exceedance of the legislation in some cases. Lead free solder is one example of this. It is predicted that half of manufacturing in major electronics sectors could be lead-free well before the 2006 deadline specified in RoHS and a number of lead free solder products are already on the market from *Sony, Ericsson* and *Philips* (GECI, 2003).

Additional market drivers are sectoral industry initiatives, finance, customer environmental and social awareness and corporate reputation/brand (Solgaard, 2000; Shapiro and White, 1997; Charter and Tischner, 2001; Croner, 2000; van Hemel and Cramer, 2002).

Industry sectoral initiatives typically arising from EPR legislation are a key driver for manufacturers of automotive, electronics and packaging goods respectively. Industry initiatives promoting technological change in line with EPR requirements e.g. lead free solder, disassembly, recovery and remanufacturing technologies are key market drivers (Mont, 2001a; Charter, 2001; van Hemel and Cramer, 2002, ECOLIFE, 2002). Some examples of the sectoral industry initiatives are summarised in **Box 5.3**.

Box 5.3 Examples of Industry Initiatives

Global industry initiatives such as the *Global Environmental Coordination Initiative* (GECI, 2002) and *Soldertec* (Soldertec, 2002) which comprise most of the major electronics OEMs provide support to the electronics sector on environmental matters with a significant focus on meeting WEEE and RoHS compliance obligations.

CARE (Comprehensive Approach for Recycling of Electronics) Vision 2000 is a voluntary, international environmental R&D network driven by the electronics industry based in Europe. The main aim is to co-ordinate an industry driven environmental research platform for the electronics industry towards sustainable products, and shared environmental responsibility (CARE, 2000).

The *European Recycling Platform* is a partnership arrangement between *Sony, HP, Braun* and *Electrolux* (at present with other electronics companies invited to join) to procure WEEE compliance services and lobby for competitive structures based on individual Producers Responsibility. This approach is distinct from consortia, already set up in a number of countries (e.g. Belgium, the Netherlands, Sweden and Switzerland), in which responsibility is shared. The intention of this approach is to stimulate a competitive recycling market for WEEE (ENDS, 2002b; Hieronymi, 2003).

A voluntary agreement exists between the EC and European, Japanese and Korean car manufacturers to achieve average new vehicle CO_2 emissions of 140 g/km by 2008 (European) (EC, 1999b) and 2009 (Japanese and Korean) (EC, 2000c, EC, 2000d) which is proposed to account for 15 % of the EU's entire commitment to cutting CO_2 emissions under the Kyoto protocol .(ENDS, 2004b).

The requirement for product differentiation in sectors e.g. electronics where standardization of technology, deregulation and globalization create fierce competition between manufacturers mean that new opportunities for product diversification e.g. through innovative functions or services which build and maintain customer relations are important drivers (Mont, 2001a). A study of the drivers for ecodesign among 77 Dutch SMEs revealed that opportunities for innovation, an expectation of increased product quality and market opportunities were the strongest drivers for ecodesign among this group. Following these drivers were customer demand, legislation and industry sector initiatives (van Hemel and Cramer, 2002).

Finance is an increasingly important market driver for sustainable products in light of the additional cost factor associated with end of life waste collection, recovery, reuse, recycling, treatment and/or disposal that EPR legislation like the ELV, WEEE and RoHS directives bring into place. This is seen as a motivational driver for producers to design out environmental issues, in particular end of life costs.

Increasing environmental and social awareness of customers is a growing, albeit slow, market driver (Solgard, 2000; MORI, 2000) This is resulting from an increase in access to global information in line with today's information society as well as globalisation facilitating global raw material sourcing and product supply (Hawkens et al, 1999; Elkington, 1997; Charter, 2001). This awareness is generating an increase in the number of stakeholders interested in the environmental and social issues relevant to products and services (Mont, 2001). Data from the *UNEP Sustainable Consumption* programme (Solgard, 2000) and the *First European Survey of Consumers' Attitudes towards Corporate Social Responsibility* (MORI, 2000) illustrate an increase in consumer awareness on the environmental and social issues associated with products. An *Environics* survey highlights that 2 in 3 citizens want companies to go beyond making profits, employing people and obeying laws to contributing to broader societal goals (Environics, 2001). While the market for sustainable products and sustainable consumerism is new, the market for the environmental dimension is growing (Solgaard, 2000; Shapiro and White, 1997). While there is scepticism of the viability of the market for green products in their own right, there is growing evidence that customers are becoming increasingly interested in the world that lies behind the products. Apart from the price and quality, they want to know where and by whom the product has been produced (Solgaard, 2000, Environics, 2001). UNEP DTIE Director describes this as:-

> *"Some time ago, industry was telling people and consumers, 'trust me'. After a number of accidents we saw consumers saying 'tell me'. Now consumers are asking 'explain to me and involve me'" (de Larderel, 1999).*

Marketing and branding the sustainability benefits of products and services is increasingly where market potential is identified (Ottman, 2002). Use of certain labels e.g. *Energy Star*, *Forest Stewardship Council* (FSC) or *Fair Trade* to market sustainability benefits are just one example of the market potential some companies associate with sustainable products. However, this is still seen as a niche market (Datchefski, 2000; Ottman, 2002). Companies incorporating EPD approaches may not always market the environmental dimension of the product. This is especially the case with compliance driven technological environmental improvements e.g. in the electronics and automotive sectors where the benefits are perceived as complex to communicate and not necessarily important in marketing terms. Examples of a selection of products and services with marketed sustainability benefits (in the main environmental) are listed in **Table 5.1**.

Table 5.1 Examples of products which explicitly market their sustainability benefits (Fuad-Luke, 2002).

Philips Marathon long life light bulbs
Café Direct Coffee
Electrolux solar lawn mower
Toyota Prius
Honda Insight
The Body Shop cosmetics
Aveda cosmetics
B&Q FSC labeled medium density fibre board
Toilet Tissue (variety of brands)
Down to Earth biodegradable plastic bags
Recycled papers and stationery products (variety of brands)
Ecover Cleaners & Detergents
AURO paint
Baygen freeplay clock radio and torch
TTS A/S Green Traffic Light, Denmark
Gea-SOL Solar Tile

Corporate reputation has for some time been a driver for improved environmental performance. Evidence of awareness of adverse environmental and social impacts associated with a product and its manufacturer has been seen to have negative impacts for some companies e.g. *Nike* and *Gap* following evidence of labour exploitation in their Asian sub supply chain companies (Klein, 2001; Nike, 1999; Nike, 2001; Munk, 1998). In light

of globalization and the increasing trend toward sub contract supply chains in the developing world, information on these practices are becoming more prominent. Company practices globally are increasingly transparent in light of today's constant media attention (Charter, 1999). For these reasons corporate reputation is a growing driver for sustainable offerings, even if the environmental benefits of a product are not deemed as directly marketable.

5.3 INDUSTRY ACTIVITIES

In response to the drivers discussed in **5.2**, evidence of EPD activities is increasingly being seen in product manufacturing companies, mainly for electronics, automotive and packaging goods with little activity in SPD (ADL, 2001; Charter, 2001; Charter and Tischner, 2001; Simonsson and Barthel, 2002; Croner, 2000). These activities can be categorised as:-

- ❑ General characteristics of company activities relating to developing sustainable products and/or services;
- ❑ Specific activities in EPD and SPD;
- ❑ Specific activities in PSS and Eco-efficient services.

The results of this analysis are presented in sections **5.3.1 – 5.3.3**. The characteristics of approaches relevant to developing sustainable products and services used by a selection of companies with documented company examples (from Data Type 1) is presented in **5.4.** A summary of industry activities relating to research and government initiatives is in **5.5.**

5.3.1 General Characteristics of industry activities relating to developing sustainable products and/or services

Manufacturing industry companies, particularly large Multinational Corporations (MNC) and OEMs, are starting to incorporate eco-design and to a very small extent SPD concepts in their product development processes[4]. This usually includes OEMs in the electronics and automotive sectors. Further, a number of sectors impacted by EPR responsibilities for packaging show evidence of EPD activities. Other sectors such as healthcare, cosmetics, construction, timber/furniture, textiles/consumer products and chemicals are also showing eco-design activities, but at a slower rate. In the retail sector, the sourcing of sustainable products has been started by companies such as *B&Q* (Jordan, 2003), *Musgrave Group* (Tonra, 2003), *Sainsburys* (Ellen, 2003), *Coop* (Zogg, 2003) and the *METRO Group* (Dobler and Sollbach, 2003). In addition to MNCs, a small number of innovative lesser known SMEs, e.g. *Avad Furniture* and *Hartmann Ltd.* (packaging) are incorporating eco-design approaches (Mitchell, 2001; Mortensen, 2003). In terms of company size, EPD activities are mainly seen in large[5] companies more likely to have greater resources and access to information on changing legal and market drivers. This is seen as increasingly filtering through the supply chain to SME companies in line with legal compliance drivers (Holmberg et al, 2000). **Table 5.2** lists examples of well known, large companies in a range of industry sectors incorporating EPD approaches to varying extents. For those MNC companies listed, it should be noted that EPD activities are not necessarily operating at all their facilities worldwide, but they have commenced and operate to varying extents. A small amount of SPD activities are practiced to varying extents. Examples include *Nike* (for shoes and apparel), *Wilkhahn* (SME, furniture sector) and *Rohner Textil AG* (SME, textile sector) (Nike, 2002; Wilkhahn, 2000; Rohner Textil, 1998).

[4] Companies may not use practitioner terms such as eco-design or SPD to describe their SPD activities. Eco-design approaches may be used in the product development process, but formal identification of this is not always made.

[5] Large is defined here as greater than 250 employees. SME is 250 employees or less.

Table 5.2 Examples of Large Companies Implementing EPD type approaches
(Sources: Philips, 1998a, 1998b, 2000b; Larson, 1997; Electrolux, 2001, 2002a; Xerox, 2001a, 2002; Smith, 1997; Klostermann and Tukker, 1998; ADL, 2001; ECOLIFE, 2002; Rodrigo and Castells, 2002; Simonsson, 2002; Mont, 2001; Reiskin et al, 2000; Charter and Clark, 1996; DEMI, 2003; Brown and Wilmanns, 1997; Gertsakis et al, 1997; Mayers, 1997; Roy, 1997; ETBPP, 1999; Hawken et al, 1999; ENDS, 2000; FT, 2000; Baynes, 2001; Paulitsch, 2001; Nike, 2002; Fuad-Luke, 2002; Schmidt, K., 2002; CfSD, 2002; Cargill Dow LL, 2002; MBDC, 2002; Nielsen et al, 2002; EU Environment Awards, 2002; Swedish EPA, 2003; Hieronymi, 2003; Waage, 2003; Panasonic, 2004; Parnell, 2004)

SECTOR: ELECTRONICS		
Philips Consumer Electronics	BASF Avant	Thomson
Electrolux	LG Electronics Inc.	Schneider Electric
Xerox	Siemens	Black and Decker
BT	Mitsubishi Electric	Océ
AT&T	Ericsson	Panasonic
SONY	Alcatel	Samsung
TRW Aeronautical Systems (Lucas Aerospace)	Motorola	Nortel Networks
Boeing	Nokia	ABB
IBM	Intel	Hitachi
ICL Fujitsu	Hewlett Packard	Lucent Technologies
Hoover		
SECTOR: AUTOMOTIVE		
Ford	Jaguar	Rover
BMW	General Motors	Saab
Volvo	Rolls Royce	PSA / Renault
Honda	Toyota	
SECTOR: PACKAGING		
UPS	Tetra Pak	L'oreal
SECTOR: HEALTHCARE		
Bristol Myers Squibb	Varian Medical Systems (diagnostic equipment)	Abbott Group (medical device packaging)
Johnson & Johnson	Proctor & Gamble	Du Pont
Body Shop International	Glaxo Smithkline	Aveda (cosmetics)
Unilever Research		
SECTOR: TEXTILES/ CONSUMER PRODUCTS		
Interface Inc.(floor coverings & carpets)	DuPont	Hess Natur (textiles)
Nike (shoes and apparel)	Patagonia (clothing)	
SECTOR: TIMBER / FURNITURE		
IKEA		
SECTOR: CHEMICAL		
BP	Cargil Dow LL	ICI Polyurethanes
Castrol (oils)	Dow Chemicals Safe Chem	
SECTOR: CONSTRUCTION		
Marvin Architectural	Blackfriar Homes, UK	Ford (Rouge assembly plant building, USA)

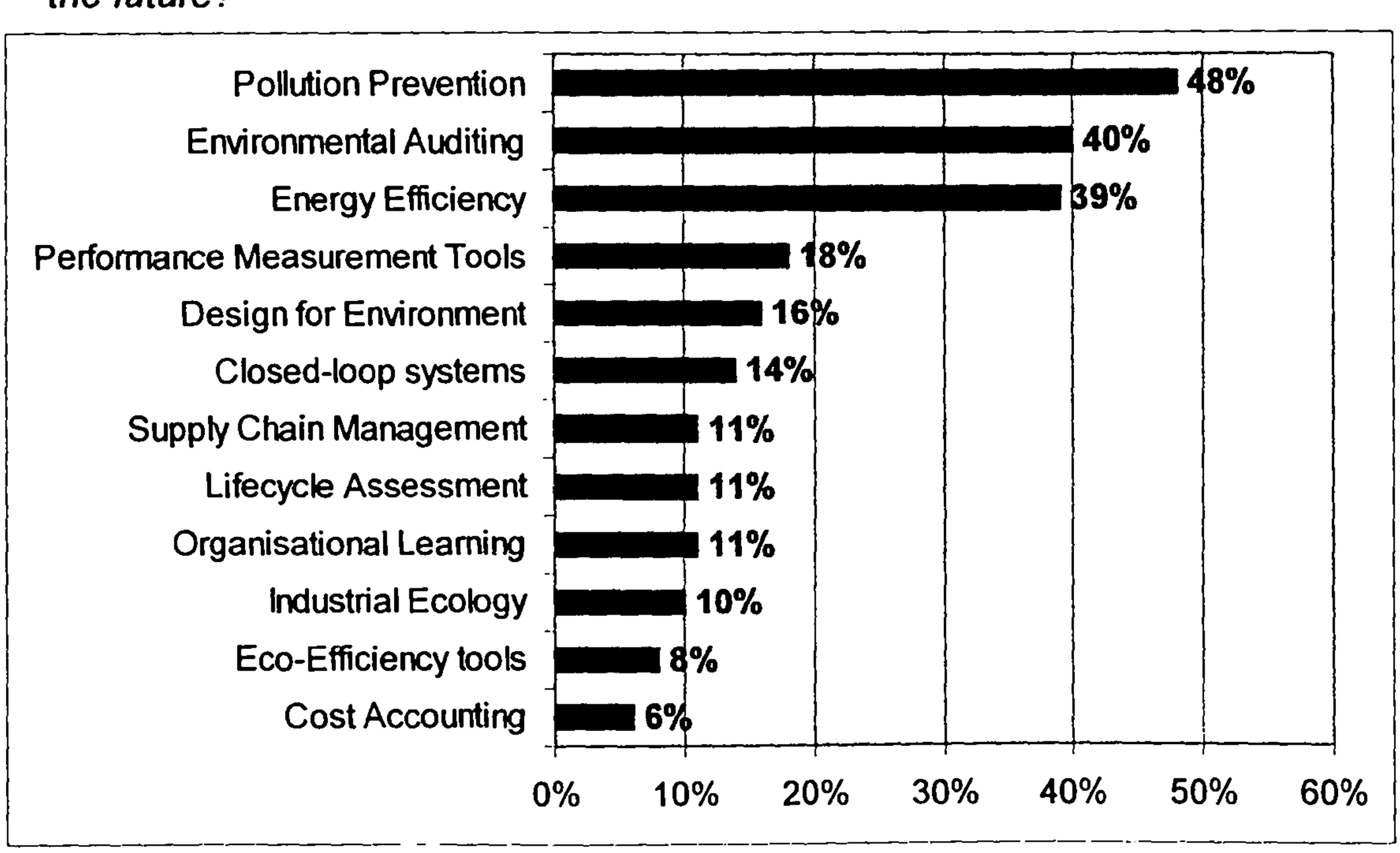
5.3.2 EPD and SPD Activities

The most common type of EPD industry activity is eco (re) design - a redesign of existing products and incorporating eco-efficiency (Gertzakis et al, 1997). It is conducted mainly at an operational, rather than strategic level (Croner, 2000; Charter and Tischner, 2001).

> *"At present eco (re) design is the dominant paradigm in business approaches to eco-design, because it fits very neatly with existing paradigms and is engineering led, rather than management or design led"* (Croner, 2000, p. 5).

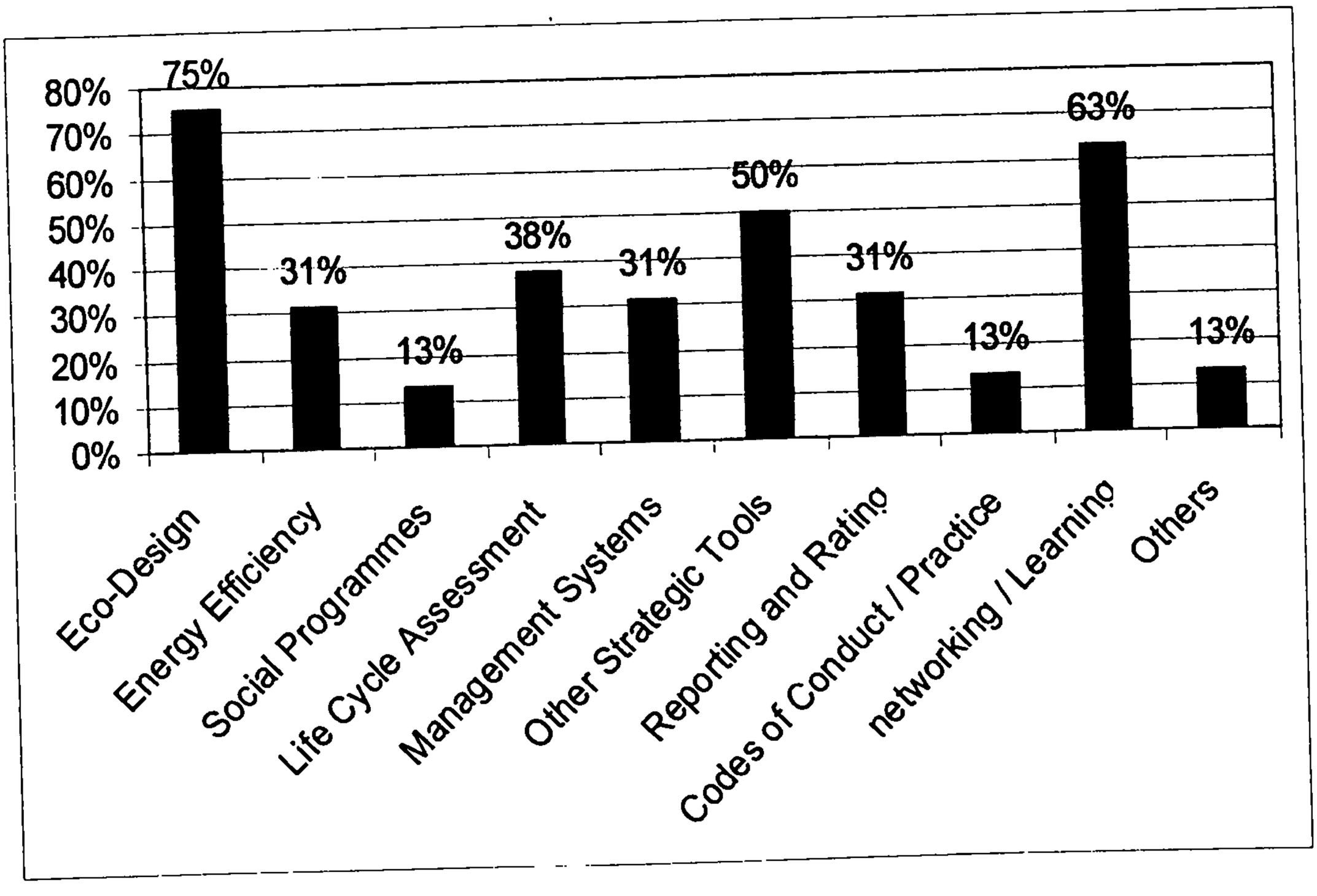
The EPD strategies focused on are mainly compliance based issues. For example in the electronics sector these are eliminating hazardous substances; end of life reuse, recovery and disposal; packaging; power management for the standby mode and cleaner production (ECOLIFE, 2002). In terms of the tools used, a mixture of the EPD methods and tools detailed in **Chapter 4** are in use. As illustrated in **Figure 5.2**, an *Arthur D. Little* survey of 481 Environment, Health and Safety and other business executives in North America & Europe showed that more traditional environmental improvement methods and tools are still the main focus of business e.g. pollution prevention (49%), environmental auditing (46%) and energy efficiency (36%). The "more innovative" tools such as Life Cycle Assessment (LCA) (11%), Design for Environment (DfE) (16%), closed loop systems (14%), eco-efficiency (8%), industrial ecology (10%), full cost accounting, (6%) and Supply Chain Management (SCM) (11%) are still in the minority of sustainability tools being used (ADL, 2001, p. 4).

Figure 5.2 Survey results Bar Graph taken from *Arthur D. Little* survey (Source: reproduced from ADL, 2001, p.4)



A survey of sixteen companies (to include *Jaguar Cars, Du Pont, HP, ABB, IKEA, RMC, Interface, Marks & Spencer*) in a UK *BSI* study on SPD type activities showed the initiatives used by these companies (Simonsson and Barthel, 2002, p. 4). **Figure 5.3** highlights the initiatives used by the companies surveyed on what SPD type activities they were using.

Figure 5.3 **Initiatives used by companies surveyed in BSI SPD Study (SOURCE:** reproduced from Simonsson and Barthel, p. 4)



Of the 16 companies surveyed, 75% used ecodesign and 38% used LCA – both specific EPD methods and tools aimed at reducing the environmental impact of products. The remaining initiatives were part of generic environmental improvement approaches (e.g. management systems, networking, learning, energy efficiency, strategic tools, reporting and rating, use of codes of conduct/practices) , aspects of which were relevant to improving the performance of products (Simonsson and Barthel, 2002).

A small number of innovative company's trailblazing ecodesign activities in industry e.g. *Philips, Electrolux* and *Xerox,* have developed customised methods and tools as well as publications for supply chain partners and other companies on ecodesign methods (Philips, 1998a, 1998b, 2000b). Internal EPD guidelines are also a feature of automotive manufacturers for example:-

- DfE (*Saab*)

- Wordwide Design Standard (*Ford*)
- Design for Recycling (*PSA/Renault*)
- Environmentally Compatible Product Design (*BMW*)
- Environmental Guidelines for Engineers (*Volvo*)
- Recycability, Recovery Guidelines (*GM*) (Rodrigo and Castells, 2002).

In terms of a lifecycle approach, very few products emerging from ecodesign are products of systematic ecodesign dealing with all lifecycle stages and few examples of consideration of functionality and determining the most sustainable way to provide it are considered (Dewberry, 1996; van Weenan, 1997; EC, 2003; Charter and Tischner, 2001). A theoretical framework for this exists but practical implementation is scarce. Life cycle stages are typically considered in isolation to meet a compliance driver e.g. end of life rather than using a full life cycle approach (Dewberry, 1996; van Weenan, 1997; EC, 2003).

TBL focused sustainability approaches, especially in relation to the development of products and services, are very few (Croner, 2001; ADL, 2001; Simonsson and Barthel, 2002). The *ADL* survey showed that only 17% of companies surveyed see themselves as well down the road in terms of implementing Sustainable Development. These are typically large companies including *Shell, Monsanto, Interface, Bristol Myers Squibb, Electrolux, Ford, Dupont* and *Nova Nordisk* (ADL, 2001; SustainAbility, 2001). Further the social aspect of TBL sustainability and how the TBL integrates is still seen as confusing (ADL, 2001, Charter, 2001, Charter and Tischner, 2001) with the ADL survey showing that social responsibility is less well understood & implemented in comparison to the environmental and economic TBL sustainability elements (ADL, 2001). The UK *BSI* study on SPD type activities showed *"little direct evidence of environmental and social issues being considered together in an integrated fashion" (Simonsson and Barthel, 2002, p. 4).*

Further, the study showed that even though the companies surveyed referred to their work as "sustainable" activities, most of the activities really only dealt with environmental aspects. The social initiatives, where conducted (as illustrated in **Figure 5.3** at only 13%), were mainly separate (Simonsson and Barthel, 2002).

The analysis revealed that innovative businesses are starting to recognise sustainability in general as a challenge, opportunity and source of competitive advantage (SustainAbility, 2001; Charter and Tischner, 2001). A number of studies are already illustrating business as well as environmental successes which may be achieved by companies incorporating a more sustainable approach to product development. These benefits include cost savings, competitive advantage and more innovative products and services, (ADEME, 1999; Maxwell, 2000; Maxwell, 2001; Hartman and Böttcher,1998; Charter and Tischner, 2001).

5.3.3 Industry Activities in Eco-Efficient Services and Product Service Systems (PSS)

There is growing research and some industry examples on the provision of functional needs through eco-efficient services or PSS with the intention of generating less environmental impact than their traditional product counterparts (Ecolife, 2002; Stahel, 2000, Mont, 1999, Reiskin et al, 2000; Brezet et al, 2001; Cooper and Evans, 2000). A small number of companies are illustrating a "servicising" shift from product manufacturers solely towards service providers selling functions through the use of PSS combinations[6]. It should be noted that these PSS initiatives are not necessarily driven by sustainability motivations, but by competitive advantage. Increasingly, servicising is being recognised as having significant potential for environmental benefits in terms of dematerialization and de-energisation (Stahel, 2000, Mont, 1999, Reiskin et al, 2000; Brezet et al, 2001). Some examples of the service aspects of PSS or eco-efficient services seen in industry include:-

- Leasing, renting;
- Pooling/sharing;
- Product life extension e.g. repair, maintenance, upgrade, end of life take back and reuse;
- Remanufacturing;
- Product substitution e.g. of electronic services for physical products;
- Consultancy, information and advisory services

[6] Details on these concepts to include eco-efficient services, PSS and Servicising are in **Chapter 4.**

- Activity management e.g. chemicals or energy management (Mont, 2001).

Examples of companies providing PSS are illustrated in **Table 5.3**

Table 5.3 Examples of Companies providing PSS (Sources: UNEP, 2002b; Mont, 2001a; Reiskin et al, 2000; Interface, 2004; Electrolux, 2001, 2002a; Xerox, 2001a, 2002; DEMI, 2003; Wong, 2004; Yang et al, 2004)

SECTOR	COMPANY	LOCATION	PSS
Textile	Interface	USA	Carpet & floor covering leasing, maintenance, end of life take back, reuse and recycling
	Du Pont, USA	USA	"
Mobility	Mobility	Switzerland	Car pooling/sharing with access to a range of vehicles on a pay for use basis with phone/internet booking
Electronics	Electrolux	Gotland, Sweden	Washing service pilot where consumers pay for washing services incorporating washing machine renting, maintenance, upgrade, end of life take back, reuse and recycling
	Océ	The Netherlands	Printer and photocopier take back, reuse and remanufacture
	Xerox	Europe and USA	Document Management Services incorporating customer needs assessment, leasing of photocopiers, printers etc. , repair, upgrade, take back, reuse, remanufacture
Chemicals	Castrol Inc.	North America	Chemical Management Services incorporating customer needs assessment, chemicals management solutions
	SafeChem, Dow Chemicals	Germany	Supply, take back and recycling

Examples of companies illustrating a servicising shift include:-

- *XEROX* moving from a photocopier manufacturer to the "Document Company";
- *IBM* from a mainframe and PC manufacturer to an information services company;
- *Herman Miller* from an office furniture manufacturer to an office furnishings service provider;
- *Electrolux* from an appliance manufacturer to an industrial cleaning service firm;
- *Castrol* from an industrial lubricant manufacturer to an industrial lubricant services supplier.

Where markets allow, these companies provide "functions" through a PSS approach, offering a product, which incorporates service elements (e.g. consultancy, product leasing, upgrade, maintenance, end of life take back, remanufacture and recycling/disposal) to provide the required functionality more effectively.

According to Reiskin, the trend towards servicising in business is arising from:-

> "*...the realisation that value is linked to the function of a product rather than the product itself. That is, customers have less interest in the physical product (the office carpet, the photocopier, the PC, the chemical solvent) than in the service delivered by such products (comfort/aesthetics, document reproduction, information processing, a clean metal surface)*" (Reiskin et al, 2000, p 1).

5.4 INDUSTRY COMPANY EXAMPLES

As part of the analysis of industry activities, the characteristics of approaches used by the following companies in the implementation of approaches relevant to developing sustainable products and/or services were analysed:-

- *Xerox*
- *Philips Consumer Electronics*
- *Electrolux*
- *Rohner Textil AG*
- *Wilkhahn.*

The companies were chosen mainly on availability of well documented case experiences relevant to developing sustainable products and/or services. In addition factors determining the choice included access to company personnel and representation of a range of industry sectors, company sizes and roles in the supply chain. The available examples focused mainly on EPD activities, in particular ecodesign. This is because few examples of TBL focused SPD approaches were identified.

Each of the company activities was analysed to determine their implementation characteristics. **Table 5.4** summarises the key characteristics of the approaches relevant to developing sustainable products and services used by each company. The implementation characteristics considered are listed in the first column of the table. These characteristics were determined based on the research into existing industry approaches relevant to developing sustainable products and/or services[7] in order to comprehensively analyse the approaches used. As background to this analysis, summaries of the approaches used relevant to developing sustainable products and services under these characteristics for each company analysed are presented in **Appendix 6.**

[7] See **Chapter 4.**

Table 5.4 Characteristics of approaches for developing sustainable products and services

Implementation Characteristics	Companies				
	Xerox	**Philips**	**Electrolux**	**Rohner Textil AG**	**Wilkhahn**
Company Size[8] Location Sector	Large (worldwide) Electronics	Large (worldwide) Electronics	Large (worldwide) Electronics	SME Switzerland Textile	Large Germany Furniture
Product/ Service/ PSS	Document Management Services PSS to include office equipment, leasing, upgrade, repair, remanufacturing	Consumer electronic products	Consumer electronic products PSS through leasing, upgrade, repair (only certain markets)	Upholstery textiles e.g. Climatex® Lifecycle	PSS to include office furniture Repair, take back, reuse, recycling and disposal
Role in supply/value chain	OEM	OEM	OEM	Material supplier to OEM	OEM
Customer(s)	Commercial & Domestic	Commercial & Domestic	Commercial & Domestic	Commercial	Commercial
SPD / EPD	EPD DfE approach called "Sustainable Product Design"	EPD Ecodesign	EPD Ecodesign	EPD	EPD

[8] Company size is defined here as either Large or SME. Large is defined here as greater than 250 employees. SME is defined as 250 employees or less.

	Xerox	**Philips**	**Electrolux**	**Rohner Textil AG**	**Wilkhahn**
Existing Sustainability or Environmental Management approach	ISO14001 multi site accreditations	POEMS with ISO14001 multi site accreditations	TNS, CSR POEMS with ISO14001 multi site accreditations	ISO14001, EMAS	ISO14001, EMAS
Drivers	Legal, market, financial	Legal, market, financial	Legal, market, financial	Sustainability strategy, legal, market, financial	Sustainability strategy, legal, market, financial
Strategy	Environment integrated into global corporate strategy & business strategic planning	Environment integrated into global corporate strategy & road maps e.g. ECO-VISION	Environment integrated into global corporate strategy, CSR & business strategic planning	TBL sustainability incorporated into Co. strategy - "Path Towards a Sustainable Company"	TBL sustainability strategy incorporating design, social responsibility & ecology
Integration with other business systems (e.g. EMS, product development etc.)	Integration in EMS, quality and product design & development process	Integration in EMS, quality and product design & development process	Integration in EMS, CSR, quality and product design & development process	Integration in EMS, quality and product design & development process	Integration in EMS, quality and product design & development process
Organisation	Cross functional teams SC involvement	Cross functional teams SC involvement	Cross functional teams SC involvement	Cross functional teams SC involvement	Cross functional teams SC involvement

	Xerox	**Philips**	**Electrolux**	**Rohner Textil AG**	**Wilkhahn**
SPD/ EPD Tools Used	DfE / ecodesign	Ecodesign, Life Cycle Thinking, customised LCA and range of custom developed tools	Ecodesign, life cycle thinking	Life Cycle Development MBDC Sustainable Design Protocol	Ecodesign, Life Cycle Thinking
Life Cycle Stages Considered	Raw materials to end of life	Concept to end of life	Raw materials to end of life	Raw materials to end of life	Concept to end of life
Consideration of Functionality & options for provision (Services & PSS)	Yes as relates to lease and take back services combined with product provision	Yes at product concept and design stages	Yes	Yes	Yes
Environmental Strategies	Extended Product Life Dematerialisation Energy Efficiency Detoxification Waste Management Design to facilitate recovery & remanufacture Asset Recycle Management	Dematerialisation Energy Efficiency Detoxification Waste Management	Dematerialisation Energy Efficiency Detoxification Waste Management	Dematerialisation Energy Efficiency Detoxification Waste Elimination Closed loop system as textile is biodegradable	Product life extension through repair, upgrade, end of life reuse , recycling and disposal, dematerialization, detoxification

	Xerox	Philips	Electrolux	Rohner Textil AG	Wilkhahn
Social Strategies	Only employee related e.g. H&S	Employee related e.g. H&S & customer oriented e.g. hazardous substances reduction	CSR programme incorporating social and environmental issues	Employee related H&S and customer oriented e.g. hazardous substances reduction	Employee related partnerships, H&S, customer, supplier, local community oriented
Other product criteria considered	All traditional e.g. quality, cost, technical feasibility	Traditional	Traditional	Traditional	Traditional
Supply Chain Interaction	Strong interaction with supply chain companies	Strong interaction with supply chain companies	Strong interaction with supply chain companies	Strong interaction with supply chain companies	Strong interaction with supply chain companies
Communications	Annual Environmental Reports Produce Environmental Management guides	Annual Environmental Reports Produce Environmental Management & ecodesign guides Internal & external green communications	Annual Environmental and Social Reports	Annual Sustainability Reports	Annual Sustainability Reports Publications on ecological performance and environmental profiles for products

	Xerox	**Philips**	**Electrolux**	**Rohner Textil AG**	**Wilkhahn**
Role in corporate image / brand /marketing	In corporate image Use of Energy Star Eco Label	In corporate image Strong marketing of Green Focal Areas in Green Flagship products	Some marketing of green product ranges	In corporate image Strong marketing	Key aspect of corporate brand image and marketing for all products and services
Language	Sustainable Product Design Waste free factories, products, workplaces	Providing more value with less impact Green Focal Areas Green Flagship Products	CSR, ISO4001, POEMS, PSS Producing more with less environmental impact	Path Towards a Sustainable Company "Virtual System Network" including, ISO9001, ISO14001, EMAS	Design, Social Responsibility and Ecology, Innovation, Ecologically orientated design & development
Environmental benefit	Yes	Yes	Yes	Yes	Yes
Social benefit (other than customer / employee related issues e.g. H&S)	No	No	Yes	No	Yes
Economic benefit	Yes	Yes	Yes	Yes	Yes
TBL Sustainability	No	No	Yes	No	Yes
Other business benefits	Yes	Yes	Yes	Yes	Yes

5.5 RESEARCH AND GOVERNMENT INITIATIVES INVOLVING INDUSTRY

To encourage industry awareness and action in EPD, a number of initiatives have been or are operating in Europe, USA, Australia and Asia to encourage EPD, mainly via eco-design approaches in industry (ADEME, 1999; Hartman and Böttcher, 1998; Gertsakis, 1997; Enterprise Ireland, 2001; Ecolife, 2002; European Foundation, 1999; Adams, 2002; UNEP WG SPD, 2000). These are typically government and/ or research initiatives incorporating participants from industry. They generally focus on reducing the environmental impacts of products, LCA or to a smaller extent SPD. The EU is increasingly investing funds in research relevant to development sustainable products and services with €150 million invested in 2001 (EC, 2001d). Networks e.g. *SusProNet*, (the EU's first Thematic Network on Product Service Development) are developing on SPD related topics (SusProNet, 2003).

Some examples of industry focused research programmes on SPD type activities include the following[9]:-

- *ECOLIFE* (a four phase project aimed at closing the loop of electronic products and domestic appliances with a focus on product planning, an ecodesign best practice guide, end of life technologies and servicising) (Ecolife, 2002; ECOLIFE network, 2002; ECOLIFE II, 2003);
- EU IPP research programme to include setting up two pilot projects, development of a green procurement handbook to increase the market for greener products, prioritising strategies for those products that are the most problematic environmentally and developing a directory of lifecycle tools (EC, 2003; Goodchild, 2004);
- EU *eLCA* project (eLCA , 2001);
- *MEPSS* project to provide industry with a PSS toolkit (PSS Information Network, 2003);
- *UNEP/SETAC* Life Cycle Initiative to develop Life Cycle Thinking industry supports (UNEP/SETAC, 2002);
- *US EPA* Life Cycle Assessment and LC Access programmes (US EPA, 2002);

[9] This does not include a range of SPD related research programmes ongoing at individual universities and other research based organisations.

- EU *ELIMA* (Environmental Life Cycle Information Management and Acquisition) research project developing innovative data collection methods and information systems to enable eco-efficient data management along the product life cycle in order to develop more sustainable products (ELIMA, 2003).

5.6 SUMMARY

The industry drivers for developing sustainable products and/or services are the increasing policy, legal and market pressures for overall sustainability improvements, reducing specific environmental impacts of certain products, and to use a life cycle approach to varying extents with EPR for the product manufacturer. These drivers have a sectoral focus and have resulted in much of the EPD activity that is evident in the targeted sectors, most notably the automotive and electronics sectors. In addition to these activities, a small number of innovative companies are illustrating elements of a more holistic TBL SPD approach as well as the use of PSS. A lack of clarity relating to how to integrate social issues, in general, as well as in the development of sustainable products and services was identified (Simonsson and Barthel, 200; ADL, 2001;Charter, 2001; Charter and Tischner, 2001). Based on the increasing industry drivers for sustainability and to reduce the environmental impacts of products, a growing requirement for a TBL focused approach for developing more sustainable products and/or services was identified.

Having identified the existing approaches (**Chapter 4**) and current industry drivers and activities (**Chapter 5**) relevant to developing sustainable products and services, **Phase I** of the research was therefore complete. Research questions 1-4 were answered:-

1. *What existing approaches relevant to developing sustainable products and/or services are available to industry?*
2. *Is there a need for a support for developing sustainable products and/or services?*
3. *What are the drivers for manufacturing industry to produce more sustainable products and/or services?*

4. *How does manufacturing industry implement approaches relevant to developing sustainable products and/or services?*

The results from **Phase I** of the research provide the basis for **Phase 2,** the development of the criteria for effective SPSD implementation and assessment of existing approaches which now follows.

SECTION III – DEVELOPMENT OF SPSD CRITERIA AND ASSESSMENT

In **Phase 2 Development of SPSD Criteria and Assessment**, the objectives to be achieved are:-

- Develop the criteria for effective SPSD implementation based on:-
  - ⇒ review existing approaches relevant to developing sustainable products and/or services;
  - ⇒ identify industry drivers and requirements for developing sustainable products and services;
  - ⇒ identify how manufacturing industry implement approaches relevant to SPSD;
  - ⇒ determine relevant factors for effective SPSD implementation.

- Assess the extent to which existing approaches meet the criteria for effective SPSD implementation.

The first objective was to determine the criteria for effective SPSD implementation approaches to incorporate industry requirements and result in the production of products and/or services with reduced sustainability impacts. This would answer research questions 5-7:-

5. *What are the requirements of manufacturing industry to produce more sustainable products and/or services?*
6. *What is effective SPSD implementation and what are the factors relevant to effective SPSD implementation.*
7. *What are the criteria for effective SPSD implementation approaches to incorporate industry requirements and result in the production of products and/or services with reduced sustainability impacts?*

Having established the criteria for effective SPSD implementation, the next element of the research was to assess the existing implementation methods against the criteria to determine whether they incorporated these criteria. This would answer research question 8

8. To what extent do existing approaches meet the criteria for effective SPSD implementation?

Section III describes the development of the criteria for effective SPSD implementation and the assessment of the existing implementation methods against these criteria. This is divided into the following chapters:-

- **Chapter 6** describes the development of the criteria for effective SPD implementation;
- **Chapter 7** describes the assessment of existing approaches.

"The economies of mass consumption that produced a world of abundance for many in the 20th century face an entirely different challenge in the 21st: to focus not on the indefinite accumulation of goods but instead on a better quality of life for all, with minimal environmental harm.",
World Watch Institute, State of the World 2004

CHAPTER 6 DEVELOPMENT OF SPSD IMPLEMENTATION CRITERIA

6.1 INTRODUCTION

This chapter describes the research conducted to develop criteria for effective SPSD implementation. The data sources and analysis conducted are described in section **6.2**. The results of the analysis – the criteria identified, are discussed in **6.3.**

6.2 DATA COLLECTION AND ANALYSIS

The research objective was to determine the criteria for effective SPSD implementation approaches. Effective SPSD implementation was defined as resulting in the following:-

- production of an offering , be it products, services or a PSS, with reduced sustainability impacts;
- meeting relevant industry requirements.

This would answer research questions 5-7. It was proposed that for any SPSD approach to be used, it needed to meet industry requirements regarding SPSD and its implementation in a company (ies).

In order to develop the criteria, representative data sources[1] relevant to developing sustainable products and/or services were used to obtain the data required. These include:-

- Literature
- Data Type 1 - Companies with documented case examples
- Data Type 2 - Companies with experience but not well documented examples
- Data Type 3 - Specialists representing research, policy and consultancy
- Data Type 4 - ESP Companies

Using these data sources, the criteria for effective SPSD implementation were developed based on an analysis of the following information:-

- Critical review of existing approaches to determine those relevant to developing sustainable products and/or services based on literature, interviews and email survey[2];
- Critical review of industry drivers for developing sustainable products and/or services based on literature and interviews[3];
- Critical review of current industry activities and specifically how manufacturing industry implement approaches relevant to developing sustainable products and services based on literature, interviews and email survey[3];
- Determining factors necessary for effective SPSD implementation based on literature, interviews and email survey;
- Determining industry requirements for developing sustainable products and/or services based on literature, interviews and email survey.

Overall, the requested data included information on the following:-

- Knowledge of industry focused implementation approaches for developing sustainable products and/or services;

[1] See **Chapter 2** for a description of these data sources.
[2] As documented in **Chapter 4** and **Appendices 4** and **5.**
[3] As documented in **Chapter 5.**

- Specific industry drivers and requirements for developing sustainable products and/or services (Note: this was the only question in the case of ESP companies);
- Factors necessary for effective SPSD implementation;
- Characteristics of implementation approaches used relevant to developing sustainable products and/or services (only for companies with experience in implementing approaches).

The templates for the interview and email survey questionnaires are in **Appendix 3**. The email survey questionnaire was used last, after data sources had been interviewed and literature reviewed. At this stage, a number of factors for effective SPSD implementation had been identified. As such, in addition to requesting the above information, the email survey respondents were asked (in a subsequent question) to agree/disagree and rank a number of factors already identified for effective implementation. In the analysis of the final data, the answers to this question were included as an additional indicator of the factors for effective implementation only. This was because the results are only for seven of the eventual sixteen criteria identified and hence the ranking was not seen as accurate data for determining the criteria. Instead the answers to the prior question on the questionnaire *"What factors do you think are necessary for effectively implementing SPSD in manufacturing industry"* were used instead.

The data sources and contact personnel as relevant from data types 1-4 are listed in **Appendix 2.** This includes contacts interviewed and respondents to the email survey. Overall, in data types 1 – 4, 106 data sources were used to include company personnel (representing in total 41 companies), practitioners, academics and policy makers. The number of interviews conducted, email surveys sent and respondents to the email survey are illustrated in **Table 6.1**.

Table 6.1 Number of interviews conducted, email surveys sent and respondents to the email survey

Interviews conducted	Email surveys sent	Respondents to email survey
80	67	48

All information collected from the data sources was maintained in a research database. The data collected were analysed to identify the criteria for effective SPSD implementation. These were collated and grouped into similar categories which formed the criteria. All the responses from each data source were used. The criteria have been developed based on this analysis and are presented in **6.3**. To facilitate presentation of the data, individual data sources relating to each factor are not identified due to the large number. Publications, as relevant are referenced.

6.3 CRITERIA IDENTIFIED FOR EFFECTIVE SPSD IMPLEMENTATION

The criteria were categorised into internal and external criteria. Internal criteria are relevant to directly implementing the SPSD process effectively in companies. External criteria are external to this process and involve policy and system conditions e.g. legal drivers or infrastructure for promoting SPSD in general and involving a range of stakeholders, not just industry. Both external and internal criteria are presented as research information, however the key focus of this research was on the internal criteria.

In order to effectively implement SPSD in industry, the following internal and external criteria were identified.

Internal Criteria

- Shifting the mindset of manufacturers from the provision of products to the provision of functions to meet human need;
- Moving from a focus on individual products to the systems in which products and services operate;
- Incorporation of all product and service lifecycle stages;
- Moving from a "greening up" environmental focus to a TBL sustainability focus;
- Incorporating a strategy level commitment to developing sustainable products and/or services and integrating SPSD with all business systems;
- Integrating TBL criteria with other traditional product and/or service criteria;
- A simple, flexible, non resource intensive, customised approach in line with business realities;
- Use of business language suited to the company and industry sector culture;
- Increased focus on supply and value chains;
- Targeting SPSD implementation at appropriate companies based on the supply chain dynamics and their control of the product and/or service conception, design and development lifecycle stages
- Integration and co-ordination of supply chain organisations;
- Availability of resources and effective communication;
- Effective organisation and management internally and across the supply chain.

External Criteria

- Strong legal and market drivers;
- Provision of a strong, clear business case for SPSD;
- Changing operating models for business and consumers.

These factors are interrelated. For clarity they are detailed individually in sections **6.3.1 – 6.3.14**.

6.3.1 Shifting the manufacturers' mindset from the provision of products to the provision of functions

The concept of selling functions or the use of products, as distinct from products and providing functions to meet human needs by not just products, but alternatives such as services or some combination of both, a PSS, are increasingly promoted as important to achieving sustainability improvements as significant environmental benefits may result (Stahel, 1997; Behrendt et al; Mont, 1999, Reiskin et al, 2000; Braungart, 2002; Brezet and van Hemel, 1997, van Weenan,1997; Hawkens et al; White et al, 1999; Engelhardt and Hammerl, 2002; Brezet et al, 2001; van Hoed, 1997; Foxon et al, 2003; Tukker, 2004). A shift in the manufacturers' mindset from the provision of products to the provision of functions which meet needs was identified as a fundamental criterion for moving towards this concept. Further, in determining the most sustainable way to provide the functionality, all options to include whether it can be provided by a service, product or PSS should be considered. An open mindset not predetermined to use products, services or PSS was seen as important to delivering original solutions (Tukker, 2003; EC, 2003c). The delivery of system focused options incorporating the offering (product, service or PSS) and the infrastructural, consumer, institutional context within which it operates as distinct from just a product focused offering was proposed (Mont, 2002; Brezet et al, 2001). Brezet calls this "Sustainable Satisfaction Delivery Systems"[4]. Mont uses the term "system of people satisfaction". Mont describes:-

> *"system based solutions" incorporating "products, services, supporting infrastructure and necessary networks" designed to "provide a certain quality of life to consumers and, at the same time, minimise environmental impacts of the system" (Mont, 2002, p. 239).*

It was also identified that when considering the wider systems, offerings are typically met through combinations of products and services based on the thinking *"that every product has some kind of service aspect and that every service is usually based on the use of several (support) products" (Brezet et al, 2001, p. 8).* Incorporating this thinking clarifies what the

[4] This is described in **Chapter 4** and **Appendix 4.**

offering is in the wider systems context. Overall, functionality with a focus on system innovations were identified as important for the development of SCP (van Hoed, 1997; Brezet et al, 2001; Mont, 2002; van Weenan, 1997). 55% of the email survey respondents identified "Shifting the manufacturers' mindset from the provision of products to the provision of functions" as a factor. Of those seven factors ranked, it was ranked on average 3rd in order of importance.

It was also identified that this approach is promoted mainly at a theoretical level, with little policy attention and few practical industry examples to date (Mont, 2002). The approach requires new business and consumer models and has many uncertainties, to include the readiness of companies to shift to this mindset, proven sustainability benefits and the ability for consumers to accept alternative offerings (Mont, 2002). Some sustainability benefits identified are outlined in **Box 6.1**[5].

Box 6.1 Sustainability benefits of a functional, systems based approach

While the sustainability benefits are still being debated, research indicates that in principle significant environmental improvements are possible by the provision of functions through eco-efficient services and PSS as distinct from products alone (Goedkoop et al, 1999; Mont, 1999; Meijkamp, 2000; Brezet et al, 2001; White et al, 1999; Behrendt, 2003; EC, 2003c; Vertujl and Tischner 2004). One of the key benefits seen from advocates of this approach is that it decouples volume (producing lots of products) from profitability & focuses on the functionality i.e. producing less product and managing it better as a PSS (Reiskin et al, 2000). Further examples of the environmental benefits identified include:-

- increased de-materialisation of product systems;
- reduced waste generation and resource usage due to the reduced volume of products produced;
- reduced waste generation and resource usage from an increase in closed loop recovery reuse and remanufacturing as well as eco efficiencies introduced into the production process.

The EC "Study on External Environmental Effects Related to the Life Cycle of Products and Services Final Report" shows that assessing the different options available to provide a

[5] For further information see **Chapter 4.**

given functionality can provide significant environmental benefits at a European level for two categories of products and services assessed (the two that have the biggest impact). These are:-

- goods and passenger transport (in particular transportation means and type of fuels),
- building occupancy (in particular type of energy consumed and energy efficiency).

For other categories, assessing the different options available to provide a given functionality can provide significant environmental benefits at a micro economic level which when added together provide a decrease in environmental impact at a European level (EC, 2003c).

Environmental benefits in terms of reduction in product volumes, reduced waste and a range of other eco-efficiencies have also resulted from PSS incorporating leasing, take back and remanufacturing activities such as operated by *Xerox* for office equipment (Phelan, 2002; Xerox, 2001). On an economic level, *Xerox* has found benefits as well (Phelan, 2002). For example in 2000, *Xerox* reduced their product material inputs by approximately 72,000 tonnes with an associated $27 million savings (Xerox, 2001).

6.3.2 Moving from a focus on individual products to systems

Based on the data, it was concluded that in order to deliver real sustainability improvements, the entire system in which the offering operates in should be considered, to include the institutional, infrastructural, network and consumer context (Brezet et al, 2001; European Foundation, 1997; Hanssen, 1999; Mont, 2002). For example, this is advocated in the methods *Design of Eco-Efficient Services* (Brezet et al, 2001), and *Sustainable Industrial Product Systems* (Hanssen, 1999)[6]. From an environmental perspective alone, Brezet highlights in the *Design of Eco-Efficient Services* method that in order to determine the most eco efficient result the following three factors must be considered in a holistic and integrated manner:-

- The device/artifact (i.e. product, service or PSS) (e.g. innovations to improve the eco-efficiency of the process, product or service;
- The physical and institutional context/infrastructure – (innovation in infrastructure/institutions related to using the products and services e.g. leasing instead

[6] For further information on these methods see **Appendix 4.**

of purchase and ownership or the new infrastructure required for hydrogen fuelled cars);

- User practice (innovation in user behaviour e.g. learning to drive a hydrogen fuelled car) (Brezet et al, 2001).

Van Weenan highlights that some sustainability problems are not due to one product type only but jointly to entire product families e.g. vehicles. Whole product families based on specific resources (e.g. fossil fuels in the transport example) have a "negative environmental potential of their own" (European Foundation, p. 12). For this reason, whole systems should be considered not just individual products. It is noted that this criterion calls for action by a range of stakeholders to include product and service providers, consumers and policy makers as well as calling for new business and consumer models *(*see **6.3.14** below*)*.

6.3.3 Incorporation of all life cycle stages

The functional based approach requires the development of an offering to start by considering the most sustainable way to provide a required functionality to meet a need. This adds in an extra offering development and lifecycle stage called "conception" where concept generation to meet a functionality occurs. Incorporation of a concept development stage to assess functionality is advocated in the EPD approaches *Promise* (Brezet and van Hemel, 1997), *Design of Eco-Efficient Services* Method (Brezet et al, 2001) and *Life Cycle Design (LCD)* Manual (Behrendt et al, 1997). The *Design of Eco-Efficient Services* Method incorporates an exploration step which considers the most eco-efficient way to provide the product and/or service. Inclusion of this step is seen as likely to give a more eco efficient result (Brezet et al, 2001).

Based on the review of how manufacturing industry implement approaches relevant to developing sustainable products and services[7], this stage is rarely included in the existing EPD approaches used in companies. To date, industry tends to implement an eco (re)

[7] This is documented in **Chapter 5.**

design approach whereby they start with an existing product and reduce the environmental impacts of this (van Weenan, 1997; Charter and Tischner, 2001; EC, 2003). The lifecycle stages considered to varying extents are typically raw material acquisition through to end of life ((ISO, 2002a). With the exception of a minority of companies, the need for a product based on the functionality required and the options for its provision (e.g. by a service or PSS) are not generally considered (Dewberry, 1996; Mont, 2002). Leaving this step out may result in the application of environmental improvement measures to a product which is inherently unsustainable, whereas the optimum sustainable solution would have been not to produce a product but say a service, or a combination of both in the first place (van Weenan, 2000; Brezet & van Hemel, 1997). As such, questioning the requirement for a product and consideration of alternative options to meet a functional requirement was identified as a criterion for ensuring a more sustainable offering is considered in the first instance. This approach requires a life cycle starting from conception through to end of life rather than from raw materials to end of life in the standard product life cycle. Overall a move away from considering life cycle stages in isolation, e.g. end of life as is the case in most compliance driven industry EPD approaches, towards incorporating the full life cycle was identified (McAloone and Holloway, 1996; McAloone and Evans, 1997; European Foundation, 1997; EC, 2003; Fava and Saur, 2002; UNEP/SETAC, 2002).

51 % of respondents to the email survey highlighted the factor "Considering all options for providing the required functionality, to include whether it can be provided by a service, product or some combination of a PSS" as important.

6.3.4 Moving from a "greening up" environmental focus to a TBL sustainability focus

Based on the review of industry approaches relevant to developing sustainable products and services it was determined that existing approaches focus on the environmental dimension of sustainability alone and in the main do not incorporate all TBL (social, environmental and economic) issues (Simonsson and Barthel, 2002; Simonsson, 2002; European Foundation, 1997; Byggeth & Broman, 2000; Charter and Tischner, 2001). If sustainability

is the aim, just reducing the environmental impact of a product using an EPD approach is not seen as enough (van Weenan, 2000; Byggeth et al, 2000; Byggeth and Broman, 2000; Hanssen, 1999; Brezet et al, 2001).

Mainstream environmental performance improvement strategies used in EPD aim to optimise environmental performance to produce less waste, emissions, pollution and more efficiency. While providing clear incremental environmental (and also economic) benefits, these are increasingly seen as "greening up" inherently unsustainable systems making them "less bad" and are increasingly being seen as inadequate in terms of achieving long term environmental sustainability, let alone TBL sustainability (Hanssen, 1999; Hawkens et al, 1999; McDonough and Braungart, 2002; European Foundation, 1997; van Weenan, 1997; Robèrt et al, 1997, Brezet et al , 2001, Roome, 2002; Hart and Milstein, 1999; Simon and Sweatman, 1997; Frei, 1998; Byggeth et al, 2000). According to Byggeth and Broman, developers of the *Method for Sustainable Product Development*, "*an environmentally adapted product is not always capable of serving as a step towards sustainability*" (Byggeth et al, 2000, p. 10).

On the environmental front alone, a shift from eco-efficiency to eco-effectiveness, aimed at maximising environmental performance as against optimising, is advocated based on closed loop, natural cycles (Hanssen, 1999; Braungart, 2002; Hawkens et al 1999; Robert et al, 2002). Closed loop, cradle to cradle lifecycles incorporating all lifecycle stages and providing for something new after each useful life is advocated in the *McDonough Braungart Sustainable Design Protocol & Cradle to Cradle Design*™ (McDonough and Braungart, 2002).

Changing the design of an individual product to reduce the environmental impact per product unit while having environmental benefits, can be off set by an increase in volume or the total use of the product. *"Products that result from ecodesign still are products and green consumption still is consumption"* (European Foundation, 1997a, p. 11). There is

growing recognition of a need to move beyond ecodesign to TBL sustainability focused approaches (European Foundation, 1997; Brezet et al, 2001; Charter and Tischner, 2001). In other words, a shift from an EPD to SPSD approach. While there are a lot of methods and tools which *"help to polish the existing frame of basically unsustainable industrial production and consumption"*, van Weenan suggests that we need to *"redesign the frame..... with sustainability in mind"* (European Foundation, 1997, p. 27). The *European Commission INNET* ("Evaluation of networking and innovation diffusion as mechanisms for sustainable production") research project highlights the importance of moving to new concepts, strategies and models for TBL sustainable production in order to make the transition to TBL sustainability a reality (Dobes and Majer, 2002). An approach which incorporates economic feasibility, environmental excellence, social responsibility and cultural diversity in the design and development of sustainable offerings to meet functional needs was identified as a criterion as well as moving away from optimising environmental impacts to maximising their performance.

6.3.5 Incorporating a commitment to providing sustainable products and/or services into the corporate strategy and from there into all existing business systems

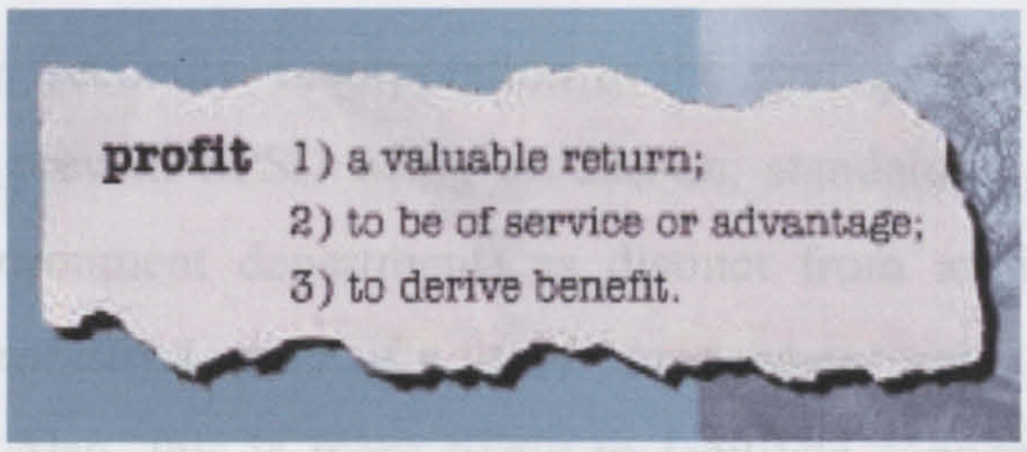
There is a growing view in the Sustainable Development (SustainAbility, 2001) as well as SPD fields (Charter and Tischner, 2001; Shapiro and White, 1999) that building in sustainability at a strategic level within industry will result in greater improvements in sustainability performance. At present most EPD methods focus at the operational rather than strategic levels with EPD being incorporated as part of the product design and development process (Croner, 2000; Charter and Tischner, 2001; Simon et al, 1998). Further, many existing EPD approaches are not integrated into product development, let alone company strategies (Byggeth et al, 2000; Byggeth and Broman, 2000; Hanssen, 1997) and standard business functions (SustainAbility, 2001). Stevels of *Philips* highlights that EPD activities should move from being a technical operations based activity to being incorporated in the *"business value chain"* (Stevels, 2000, p. 2). *Philips* have illustrated this approach as implementation of ecodesign activities at *Philips* has evolved from an

originally *"design focused activity"* to a *"product and design management"* focussed approach, and subsequently to a strategic approach embedded in all levels of the business (Sherwin et al., 2002, p. 2)[8].

Incorporating a commitment to developing sustainable products and/or services at the earliest possible stage and ideally into the existing corporate business strategy and strategic plan was identified as essential to ensuring that SPSD type approaches are effectively implemented (McAloone, 2000; Hanssen, 1997; Argument et al, 1998; Ottman, 2002; Stevels, 2000; Hoed, 1997; Brezet et al, 2001). A UK *BSI* survey of SPD type activities in 16 companies and the views of six key SPD experts showed that most respondents saw the presence of a *"sustainability policy or corporate strategy"* facilitating initiation and maintenance of these activities (Simonsson and Barthel, 2002, p. 1). Based on the review of company activities relating to developing sustainable products and services, companies such as *Philips, Xerox, Electrolux, Johnson & Johnson, Wilkhahn* and *Rohner Textil*, highlight the use of strategies and strategic plans as success factors in achieving improved sustainability performance in their products and services (Stevels, 2000; Kalin, 2002, Phelan, 2002, Larson, 1997, Schmidt, 2002). *Rohner Textil* explicitly illustrates this commitment through their corporate strategy entitled "Path Towards a Sustainable Company" (Kalin, 2002). *Cargil Dow LL* (developers of the Nature Works™ product, a plastic alternative made from corn maize) have a TBL based company strategy. Further, they have adopted a broad definition for achieving profit based on sustainability concepts as illustrated in **Figure 6.1**.

[8] For further information on the *Philips* approaches relevant to developing sustainable products and services see **Chapter 5**.

Figure 6.1 ***Cargil Dow LL*** **Definition of Profit** (Source: Cargill Dow LL, 2002)



Their products are assessed on a sustainability basis in terms of the following:-

- ❑ better performance;
- ❑ economic viability;
- ❑ social responsibility and
- ❑ environmentally sound (Cargill Dow LL, 2002).

Incorporation of a commitment into the existing business strategy was seen as necessary for integrating SPSD type approaches throughout the company's business systems to include product design and development, environmental management, health and safety, quality, purchasing, finance and marketing. This integration was seen as necessary for effective SPSD type implementation (Shelton, 1995; Frei, 1998; McAloone, 2000; Stevels, 2000; Tischner et al, 2000; Neilsen, 2002; Mont, 2001; Byggeth and Broman, 2000). All business functions, not just environmental and product development, should be incorporated. This is for a number of reasons. Firstly, a more sustainable outcome was seen as more likely if sustainability concepts were incorporated at the earliest stage e.g. concept generation and within the broadest possible business functions. EPD and product development research has shown that in most cases approximately 80% of the environmental impacts as well as costs associated with all life cycle stages of a product are determined at the design stage (Ecolife, 2002). Hence incorporation of sustainability concepts at the earliest stages, ideally at concept generation and design was identified as key. Prior to design, decisions in other business functions e.g. business planning, marketing and finance may already have been made which will impact the scope of sustainability benefits likely from the outcome

(Ecolife, 2002). Secondly, incorporation in the strategy and into all business functions is more likely to prevent SPSD being an add-on, standalone activity (driven solely by the company's environment department) as distinct from an integrated approach (Shelton, 1995). *"Sustainability is part of normal management not a single activity"* (Charter and Kajzer, 2002). Also, this is more likely to facilitate support at a corporate and business function level to include provision of necessary resources and co-operation (Blaza, 2001). Thirdly, this facilitates integration of sustainability with traditional product or service criteria also identified as an important factor (see **6.3.6**). Companies implementing approaches relevant to developing sustainable products and/or services (mainly EPD) have incorporated this approach to varying extents in the existing business systems. Some MNC implementing eco-design, have integrated it into the companies' existing systems for product design and development and to meet the requirements of quality and environmental management programmes. For example, *Nike, BP,* and *IKEA* have integrated eco-design into their TNS (The Natural Step) approach (Rowland and Sheldon, 1999; TNS, 2000; Andersen, 2003; Parnell, 2004; Interface, 2004). *IBM* are linking ISO14001 to its Environmentally Conscious Products (ECP) programme, *Electrolux, Xerox* and *Philips* include eco-design in their EMS with *Electrolux* and *Philips* using a Product Orientated Environmental Management System (POEMS) (Croner, 2000; Meinders, 1999; Electrolux, 2002a; Xerox, 2002).

74 % of respondents to the email survey highlighted the factor "Incorporating a commitment to SPSD into the corporate strategy and from there into all business systems to include sustainability / environmental management and product development systems" as important. Of the seven factors presented in the survey, it was ranked on average number one in order of importance for effective SPSD implementation.

6.3.6 Integration of all triple bottom line criteria (social, environmental and economic) with other traditional product and/or service criteria

In addition to integration of TBL criteria, the integration of the SPSD approach with traditional key business criteria was identified as an industry requirement to ensure a practical offering workable on all business levels (Hanssen, 1997; Mont, 2002; Tukker, 2003; Ottman, 2002; Byggeth and Broman, 2000; Tischner et al, 2001; Stevels, 2000). Integration of TBL criteria with traditional product and service criteria e.g. functionality, economic, quality, market, customer requirements, technical feasibility and compliance issues was identified as a key industry requirement. It was highlighted that there was no point developing a more sustainable offering if it does not effectively meet consumer needs, provide the required functionality, is profitable, feasible to provide, meet quality and legal compliance requirements and increases market share and opportunities for competitive advantage. In terms of meeting customer need, the *Philips* ecodesign approach highlights that assessing and understanding the customers' requirements, value perception and benefits associated with the development of sustainable products and services is key to a successful result. While these may include environmental or social benefit there can also be cost benefits or immaterial and emotional benefits e.g. an offering which is more fun or easier to use or gives a feel good factor from durability or recyclability or a feeling of safety associated with removal of certain hazardous substances (Stevels, 2000a; Ishii and Stevels, 2000).

The *Philips* ecodesign approach also highlights that while integration with traditional criteria is key, the early stages of an offerings development (i.e. concept generation and design stages) should focus on creativity in identifying environmental benefit in the first instance and not be limited by day to day business issues. Once the idea generation phase has occurred the proposed options resultant can be assessed in terms of the standard business criteria (Stevels, 2000).

60 % of respondents to the email survey highlighted this factor as important to effective SPSD implementation[9].

6.3.7 Use of a simple, flexible, qualitative, non resource intensive, customised approach in line with business realities

In addition to embedding a commitment to developing a sustainable offering into the corporate strategy and integrating it with the company's existing business functions, it was identified that SPSD implementation will only be effective if it is pragmatic, flexible, customised and is in line with business realities. 90 % of the interviewed data sources, to include all companies and practitioners, identified this as a criterion. 83% of the email survey respondents ranked the factor "Simple, flexible, qualitative approach backed up by quantitative tools as required" as important for effective SPSD implementation.

Research involving *IBM, Bristel Myers Squibb* and *Armstrong World Industries* (Shapiro and White, 1997), recommended such an approach on the eco-design front. This is seen as even more important for the more holistic TBL SPSD approach. Further, it should not be overly resource intensive in terms of time, cost or personnel especially in light of the typically short time span from product concept to market (Shapiro & White, 1997; Stevels, 2000; Adams, 2002). For example, the *European Information, Consumer Electronics and Communications Technology Industry Association EICTA* highlight that for these sectors, the ability to innovate and quickly get a product to market is often critical in ensuring competitiveness (Adams, 2002). There is a growing recognition that EPD approaches and tools can be complex, highly quantitative and resource intensive in terms of the expertise, personnel, time and costs incurred for implementation (Dewberry, 1996; van der Vorst et al, 1999; Charter and Tischner, 2001; Holmberg et al., 2000; Datschefski, 2001).

[9] This factor was presented in the questionnaire as the integration and "optimisation" of TBL criteria with traditional criteria. As already discussed, other data showed that "optimisation" needed to move towards maximising environmental performance. Therefore, this was subsequently incorporated in the criteria, rather than optimisation.

A rigid, procedural framework was identified as a barrier for effectively implementing sustainability into product and service development (Brezet et al, 2001; Nielsen et al, 2002; Ecolife, 2002). This was due to SPSD type implementation requiring a customised approach in line with the product and/or service and organisations involved (Nielsen et al, 2002; Charter, 2001, Ecolife, 2002). Existing company EPD approaches (such as those used in *Philips, Xerox* and *Electrolux*) typically incorporate a range of tools which have been developed by the company or customised to their needs (Philips, 1998a; Meinders, 1999; Thompson and Sherwin, 2001; Xerox, 2001a; Phelan, 2002). Developing sustainable products and services was seen as a dynamic process which evolved, as distinct from a static process, and which required creativity and inspiration as distinct from rigid procedures (European Foundation, 1997a; Brezet et al, 2001; Nielsen et al, 2002). Due to the number and diversity of concepts and tools which can be used in SPSD type implementation, the requirement for an overall guidance approach supported by relevant tools, as required was identified (Brezet et al, 2001; Ecolife, 2002). Therefore the requirement for a flexible framework providing a guide for implementing SPSD in the form of suggested actions supported by information and examples to inform and inspire the user and a flexible toolbox allowing for evolution of the SPSD approach was identified. The flexibility should incorporate the ability to customise the approach on a case by case basis in line with factors such as the company(ies) culture, sector, products and services, drivers, organisational structure and existing business systems (Nielsen et al, 2002; Ecolife, 2002). Incorporating these views, a requirement for a qualitative, flexible, pragmatic guide customised to a company's existing business and product/service strategies which is supported, as relevant, by suitable tools was identified as an industry requirement.

6.3.8 Use of business language suited to company/industry sector cultures

All data sources highlighted the importance of the use of business language in the communication of SPSD type concepts. 69 % of respondents to the email survey highlighted this factor as important to effective SPSD implementation and on average ranked it second out of the seven factors presented.

In particular the existing specialist terminology used generally amongst a small circle of experts involved in activities relevant to developing sustainable products and services (e.g. PSS, DfE, ecodesign, eco-efficient services, eco-services, EPD, LCA) was seen as a barrier for effective SPSD implementation in industry and that clarification, simplification and translation to corporate language was required (Mont, 2001; Maxwell and van der Vorst, 2003; Nielsen et al, 2002). The need for integration of SPSD with other business functions and the interaction of multidisciplinary personnel underlines the importance of using a business language suited to the company/industry sector culture (Nielsen et al, 2002).

6.3.9 Increased Focus on Supply and Value Chains

The role of the supply chain in effectively implementing SPSD was identified as important from two key perspectives. Firstly, the focus for targeting SPSD implementation should be on the product and/or service supply chain rather than on individual companies. Secondly, effective interaction and co-ordination between organisations was seen as key to effectively implementing SPSD. Each of these is detailed below.

6.3.9.1 Targeting SPSD implementation at appropriate companies based on the supply chain dynamics and their control of the product and/or service conception, design and development lifecycle stages

Data sources highlighted that determining the most effective target organisation for SPSD implementation and the role Supply Chain Dynamics (SCD) played in this was important for effective SPSD implementation. Overall, determining the most effective target organizations for SPSD was seen as a crucial element, which is largely left out of existing SPSD type approaches, as well as broader environmental performance improvement measures in industry to date (Laurent and Duckers, 2000). This is increasingly viewed as missing and seen as important not only for effective eco-design implementation (Shapiro and White, 1997; Charter et al, 2001; Croner, 2000; Tischner, 1999; Morton, 1999), but

also for achieving environmental improvements in companies, in general (UNEP, 2002; US EPA, 2001).

It was identified that most existing approaches relevant to reducing the sustainability impacts of products e.g. eco-design, are aimed directly at individual companies irrespective of their role in the supply chain and the wider product SCD. Further, there is a trend towards developing eco-design and SPD tools in line with company size e.g. large or SME as per traditional environmental improvement approaches. These were identified as barriers to effective SPSD and an alternative approach initially focusing on the supply chain, as distinct from at individual company level is proposed.

Early on, the research revealed that with the exception of products manufactured in a direct B2C relationship, most products with significant sustainability impacts, e.g. cars or electronics goods, are manufactured using a number of companies involved in a supply chain. Typically, this will involve an OEM and a range of component suppliers, sub component suppliers (to many tiers potentially) and assemblers. Typically the OEM has control over the product and/or service design and specification. The other companies, in the supply chain, supply and/or assemble their elements in line with this. In light of this, it is proposed that the supply chain for a proposed product and/or service must be considered in order to determine which company (ies) within the supply chain will be the most effective targets for SPSD as well as its different aspects. Further, it was identified that it is necessary to target the organisations with control over the product life cycle stages where most sustainability issues can be most effectively tackled – typically the product conception and design phases. It is at these stages that most (up to approximately 80%) of the environmental, social and cost factors for a product are determined (Ecolife, 2002; Charter and Tischner, 2001). Hence, it is at this stage that truly effective improvements can be made not only in terms of sustainability issues, but also potentially in terms of cost (Maxwell, 2001; Datschefski, 2001).

There is a trend towards targeting environmental performance improvement methods at organisations based on their size. For example, much work has been done to formulate environmental performance improvement approaches, to include eco-design, specifically to engage and meet the needs of SMEs. It is reasonable to apply environmental performance improvement systems e.g. EMS directly to SMEs as SMEs have control over activities at their production facilities and can manage their environmental impacts. However, the same rationale is not necessarily relevant for products as many companies in the supply chain (e.g. suppliers and assemblers), often SMEs, may not have this control and need to work in conjunction with the OEM to change the product specification.

Irrespective of company size (large or SME), it was identified that SPSD will be more effective if targeted at the organisations that have control over key product life cycle stages, particularly the conception and design phases. It is proposed to move the focus away from the size of the company (large or SME) to incorporation of the SCD relevant to the product supply chain. The SPSD approach may then be spread out to other organisations involved in the supply chain either upstream or downstream as relevant (e.g. in the form of specifications for the offering). It is proposed that through this approach, the roles of large and SME organisations in making products and/or services more sustainable, can be most effectively utilised. Using this approach, SPSD implementation may be applied through the supply chain depending on the SCD. This shift in focus away from an individual company towards the product and service supply chain could lead to a paradigm shift in how we apply sustainability approaches in product and service development.

65 % of respondents to the email survey highlighted this factor as important to effective SPSD implementation and on average ranked it fifth out of the seven factors presented.

6.3.9.2 Integration and co-ordination of the Supply and Value Chain

The interaction, communication, co-ordination and management between the organisations in the supply chain was identified as key for effective implementation (Dewberry, 1996; McAloone, 2000; Brezet et al, 2001; Ecolife, 2002; Charter, 2001; Dobes and Majer, 2002; DEFRA, 2002; Phelan, 2002; Meinders, 1999; Stevels, 2000; Simonsson and Barthel, 2002; Simonsson, 2002; Skoecz, 1999). This is because firstly, products and/or services are created along supply and value chains and secondly, the significant volume and diversity of issues to be incorporated in SPSD. There is also a synergy between lifecycle and the value chain approaches (Diehl and Crul, 2002). In particular, co-ordinated working between the suppliers (especially second and third tier suppliers) with each other and the OEM was identified as important for SPSD type implementation (Simonsson and Barthel, 2002; Diehl and Crul, 2002).

At present a lack of integration of sustainability issues in Supply Chain Management (SCM) approaches was identified with the key focus being on greening the supply chain where this exists (Charter, 2001). While environmental focused SCM is increasing in industry this is still mainly seen in MNCs in the electronics and automotive sectors based on compliance drivers with some activity also in large retailers e.g. *B&Q* (Croner, 2000; Charter, 2001; ESCF, 2001; Ishii and Stevels, 2000; Jordan, 2003). Key areas of supply chain interaction relevant to SPSD identified include:-

- Information collection (Life Cycle Data Acquisition (LCDA)) and provision;
- Material procurement;
- Component assembly;
- Recovery, take back, remanufacturing, recycling and disposal;
- Training.

Existing implementation approaches relevant to SPSD at individual company level were seen as not sufficient with the recommended focus at network level. Implementation across

networks of organisations across the supply chain with joint goals was seen as necessary for a more sustainable result (Dobes and Majer, 2002; Brezet et al, 2001). Product and service development teams incorporating representatives from relevant supply chain organisations were advocated. Effective co-operation, interaction, dialogue and partnerships were identified as necessary to facilitate information transfer (Ecolife, 2002). Further this was seen as beneficial for strengthening of supply/value chain capabilities and relationships (Simonsson and Barthel, 2002).

6.3.10 Availability of Resources and Effective Communication

The need for appropriate resources in terms of skills, knowledge, investment and information (Brezet and van Hemel, 1997; Stevels, 2000; Simonsson and Barthel, 2002; van Hemel, 2002) were identified as important for effective SPSD type implementation. Due to the volume and diversity of information pertinent to developing sustainable products and/or services, the requirement for dynamic access to information and knowledge through external/internal supports, communication, networking and training was identified as a criterion (Lenox and Ehrenfeld, 1996; Dewberry, 1996; European Foundation, 1997a; Hanssen, 1997; McAloone, 2000; Brezet et al, 2001; Charter, 2001; Ecolife, 2002; Nielsen et al, 2002). As highlighted by the European Foundation Sustainable Development and SPD research project *"Information is important, but knowledge is essential and vision is vital"* (European Foundation, 1997b, p. 22). Information and knowledge relating to assessing the environmental, social and economic impact of products and services, compliance requirements, technical specifications from suppliers and customers, technical innovations and market developments were all specified as key information requirements. Knowledge and communication were seen as key enablers for SPSD implementation in companies, in particular with respect to acquisition of technical knowledge (Simonsson and Barthel, 2002). Access to ongoing updated knowledge was seen as key to realising continuous improvement as well as ensuring competitive advantage (Ecolife, 2002). *Philips* and *Xerox* highlight effective environmental communication both internally and externally

to a range of stakeholders as a success factor in their ecodesign approach (Stevels, 2000a, Ottman, 2002; Phelan, 2002).

6.3.11 Effective organisation and management internally and across the supply chain

A range of factors relating to the organisation and management structures required for effective SPSD implementation were identified as criteria to include:-

- Requirement for an initiator in the form of an organisation, company and internal champion (McAloone, 2000; Brezet et al, 2001).
- A multidisciplinary approach incorporating cross functional teams representing the different business functions in particular marketing, planning, procurement, sales and finance in addition to product designers, production engineers, environmental and social related expertise. These were seen to be relevant both internally within an organisation, as well as externally across the supply chain (Hanssen, 1997; Stevels, 2000; McAloone, 2000; Charter, 2001; Simonsson and Barthel, 2002).
- Appropriate management structures to facilitate the buy in and involvement of management from all business systems (van der Hoed, 1997; Stevels, 2000; Byggeth et al, 2000; Byggeth and Broman, 2000; Mont, 2001; ECOLIFE, 2002).

6.3.12 Strong Legal and Market Drivers

Data sources identified external pressure on industry from legal and market drivers (especially customers) as necessary to motivate industry to develop sustainable products and/or services (Hanssen, 1997; Argument et al, 1998; McAloone, 2000; Stevels, 2000; van Hemel, 2002; Ryder, 2004). The UK *BSI* survey of SPD type activities showed external drivers e.g. legislation as the most common factor for initiating and maintaining these activities (Simonsson and Barthel, 2002). Increased pressures from legal and market

drivers for these activities were highlighted as necessary to drive the shift towards sustainability[10].

6.3.13 Provision of a clear, strong business case for SPSD

A demonstrable business case for developing sustainable products and/or services was identified as a criterion. This should illustrate the business benefits in terms of profitability, potential for competitive advantage, opportunities for innovation, improved market share and business development (McAloone, 2000; van Hemel, 2002; Tukker, 2003).

6.3.14 Changing operating models of business and consumers

Due to the shift in focus towards provision of functionality as distinct from products through system based offerings being increasingly advocated as important for sustainability improvements (as discussed already in 6.3.1 above), the requirement for new business and consumer models to support this transition was identified (Dewberry, 1996; Mont, 2002; Dobes and Majer, 2002; Brezet et al, 2001) as a criterion.

On the business side, changing the mindset of product and service providers from a short term economic focus based on shareholder bottom line to a longer term focus based on satisfying a wider range of stakeholders and business benefits is required. This incorporates the success of business being based not on the bottom line alone, but including criteria such as generation of community wealth, protection and restoration of natural systems and leadership (Braungart, 2002; Winslow, 2002; Elkington, 1997, Hawkens et al, 1999). Market economy systems based on economic success factors alone has been highlighted as a barrier to SCP (Brezet, 2004, Young, 2004, Ryder, 2004). There is a time factor shift required also to focus on longer term profit vs. short term (Brezet et al, 2001). SPSD approaches may not always yield short term benefits. Further the shift in mindset and the learning curve to incorporate thinking relevant to SPSD requires a significant development

[10] For further information on the legal and market drivers see **Chapter 5**

process for industry (McAloone, 2000; Braungart, 2002; Winslow, 2002; Blaza, 2001). This shift requires responsibility from product and service providers for the full lifecycle requiring greater involvement and interaction with consumers and organisations in the value chain at an early stage of the offerings development (Mont, 2002; Brezet et al, 2001). Additional business coalitions, networking and interaction with a wider group of stakeholders are a likely feature of these new business models (Dobes and Majer, 2002; Brezet et al, 2001). As highlighted by the *EC INNET* research on the requirement for incorporation of a range of stakeholders in the transition to sustainable production:-

> *"It is not sufficient to complete this mental change on an individual level. It has to be integrated on the group level, on the organizational level and on the network level. The same change has to happen within the external institutional environment"* Dobes and Majer, 2002, p. 3).

On the consumer side, shifting the mindset of consumers from being owners of products to being users of system offerings will require greater consumer involvement, education and information (Mont, 2002) .

6.4 DISCUSSION

This chapter describes the development of the criteria for effective SPSD implementation. Effective SPSD implementation is defined as incorporating industry requirements and resulting in the production of products and/or services with reduced sustainability impacts. The development of the criteria was based on a range of data sources, as discussed which were collected and critically analysed. This answered research questions 5-7:-

5. *What are the requirements of manufacturing industry to produce more sustainable products and/or services?*
6. *What is effective SPSD implementation and what are the factors relevant to effective SPSD implementation.*
7. *What are the criteria for effective SPSD implementation approaches to incorporate industry requirements and result in the production of products and/or services with reduced sustainability impacts?*

The criteria identified include internal (relevant to the implementation approach) and external criteria (relevant to the larger systems, infrastructure and policies industry operates in). Both the internal and external criteria are results from the research. The internal and external criteria highlight a number of barriers to developing sustainable products and/or services in industry (Maxwell et al, 2003a). As this research is focusing specifically on identifying the criteria for SPSD implementation approaches for industry, the internal criteria were translated into the following criteria for an SPSD implementation approach. The external criteria relating to "Provision of a strong, clear business case for SPSD" was incorporated in the context of information provision of the business case for SPSD. Incorporating those criteria that were relevant to an implementation approach for developing sustainable offerings was seen as important to overcoming these barriers and facilitating the development of sustainable offerings.

Criteria for effective SPSD implementation relevant to an implementation process

1. A simple, flexible, non resource intensive, customised approach based on a qualitative framework guide of suggested actions with suitable quantitative supports as necessary;
2. Shifting the focus from the provision of products to the provision of functions and considering all options for providing the required functionality, to include whether it can be provided by a service, product or some combination of a PSS;
3. Consideration of the systems in which the product and/or service currently/will operate in;
4. Incorporation of all product and/or service lifecycle stages
5. Use of a strategy level approach incorporating a strategy level commitment to developing sustainable products and/or services;
6. Integration of SPSD into existing business systems;
7. Shifting the focus from a "greening up" environmental focus to a TBL sustainability focus and integrating TBL sustainability criteria with other traditional product and/or service criteria;
8. Use of business language suited to the company/industry culture;

9. Considering the Supply Chain Dynamics (SCD) of the product and/service supply chain to determine the most effective target company (ies) for SPSD implementation (i.e. company (ies) with control of the product and/or service conception, design and development lifecycle stages) and for implementation up and down the supply chain.
10. Incorporating guidance for effective integration and co-ordination of supply chain organisations;
11. Provision of relevant supporting information to include the business case for implementing SPSD, legal and market drivers, compliance requirements, standards and innovative case examples;
12. Incorporating guidance for effective communication, organisation and management internally and across the supply chain.

The intention is that these criteria incorporated within a SPSD implementation approach will result in effective SPSD implementation.

6.5 SUMMARY

Having established the criteria, the next element of the research was to assess the existing implementation methods relevant to developing sustainable products and/or services against the criteria to determine the extent to which they met these criteria and what new aspects would be required for a new SPSD approach. This is described in **Chapter 7.** Further, the criteria are used in conjunction with the assessment results in the development of the SPSD approach which is documented in **Chapter 8**.

"Business cannot escape from the sustainability imperative. It must realise that all of its future opportunities will be solutions to the critical equation of sustainability"
Claude Fussler, World Business Council for Sustainable Development

CHAPTER 7 ASSESSMENT OF EXISTING APPROACHES AGAINST SPSD IMPLEMENTATION CRITERIA

7.1 INTRODUCTION

Based on the Phase 1 data collection and analysis, key criteria relevant to effective SPSD implementation in industry were defined. The next research question was:-

8. To what extent do existing approaches meet the criteria for effective SPSD implementation?

In order to determine to what extent the previously identified implementation methods relevant to SPSD incorporate these criteria, they were assessed. Based on the previously identified methods reviewed[1], twenty two implementation methods were chosen for more detailed assessment. This chapter describes the assessment conducted. The assessment aims, criteria and protocol are summarised in **7.2**. The assessment results are in **7.3.** This is supplemented by an assessment matrix illustrating the results in **Table 7.3**.

7.2 ASSESSMENT PROTOCOL

The twenty two methods relevant to SPSD implementation were assessed against the SPSD implementation *criteria* with the intention of identifying the extent to which the criteria were incorporated, how and what criteria were missing. The purpose of the assessment was not to consider the pros and cons of the implementation methods assessed but only whether and how they incorporated the criteria or not in order to learn lessons from this. This information could then be used in the development of the new SPSD approach. The pre-

[1] See **Chapter 4** and **Appendices 4** and **5,**

defined assessment criteria enabled an objective, systematic review of the identified methods.

7.2.1 Assessment Criteria

The assessment criteria identified for SPSD implementation methods to result in effective SPSD implementation (to include the shorthand for each criteria used in the results assessment matrix at Table 7.3) are listed in **Table 7.1**. These are the assessment criteria used.

Table 7.1 Assessment Criteria and Shorthand used in the Assessment Matrix

Assessment Criteria	Shorthand used in the Assessment Matrix
A simple, flexible, non resource intensive, customised approach based on a qualitative framework guide of suggested actions with suitable quantitative supports as necessary;	Simple, flexible guide
Shifting the focus from the provision of products to the provision of functions and considering all options for providing the required functionality, to include whether it can be provided by a service, product or some combination of a PSS;	Functionality
Consideration of the systems in which the product and/or service currently/will operate in;	Systems
Incorporation of all product and/or service lifecycle stages	Full lifecycle
Use of a strategy level approach incorporating a strategy level commitment to developing sustainable products and/or services;	Strategic
Integration of SPSD into existing business systems;	Integrated in business systems
Shifting the focus from a "greening up" environmental focus to a TBL sustainability focus and integrating TBL sustainability criteria with other traditional product and/or service criteria;	Integration of TBL
Use of business language suited to the company/industry culture;	Business Language
Considering the SCD of the product and/service supply chain to determine the most effective target company (ies) for SPSD implementation (i.e. company (ies) with control of the product and/or service conception, design and development lifecycle stages) and for implementation up and down the supply chain.	Targeting implementation based on SCD (Supply Chain Dynamics)

Incorporating guidance for effective integration and co-ordination of supply chain organisations;	SCM (Supply Chain Management)
Provision of relevant supporting information to include the business case for implementing SPSD, legal and market drivers, compliance requirements, standards and innovative case examples;	Information supports
Incorporating guidance for effective communication, organisation and management internally and across the supply chain.	Comms, Organisation, Management

7.2.2 Implementation Methods Assessed

As already described in **Chapter 4,** a wide range of existing approaches relevant to developing sustainable products and /or services were critically assessed as part of this research. Of these, methods which could be used for aspects of SPSD implementation in industry were identified and a representative sample selected for more detailed assessment against the criteria. The methods chosen were existing published methods providing a framework for implementation activities relevant to developing sustainable products and/or services within product and/or service providers and available for industry to use (i.e. not in house proprietary, customised company methods inaccessible to other companies). Some of these are designed as implementation guides specifically, but not all. They were chosen as they could be used by companies for implementation as this is the focus of the SPSD process and could be learned from in this context. Philosophies or concepts alone were not chosen for this assessment, nor were specific tools e.g. Life Cycle Assessment (LCA) or Design for "X", but implementation methods (in many cases incorporating a range of tools as part of the implementation).

The methods assessed include the two SPD implementation methods[2] identified and a sample of twenty EPD implementation methods[3]. Most of the existing implementation methods identified focus on EPD implementation activities e.g. ecodesign, and the twenty methods chosen are representative of the different strategies and media used. They

[2] A description of these methods is in **Appendix 5**.
[3] A description of these methods is in **Appendix 4.**

originate from a range of countries but only methods in English were chosen. In total, twenty-two methods were assessed as listed in **Table 7.2**.

The format of the methods assessed varies. In the main, the format is implementation guides. Some are text books, paper based guides, online web based guides as well as two standards, one PhD thesis with published papers and one as a published paper. While all of the methods assessed are not meant as standalone implementation guides and cannot be assessed equally as guides, they provide an implementation approach relevant to developing sustainable products and services in industry to different extents. A range of the existing implementation methods available are sectorally focused in particular for electronics, hence several of those assessed are aimed at the electronics sector (methods 16-20). While these focus on one sector and SPSD is to have cross sector application, it was seen as important to include the sectorally focused methods chosen as these are existing, representative implementation guides.

References, method numbers and shorthand for each implementation method are also included in **Table 7.2**. The method numbers and shorthand are used to identify each method in the subsequent results assessment matrix at **Table 7.3** and in the results discussion in section **7.3**.

Table 7.2 Implementation Methods Assessed (with References, Matrix Method Number and Shorthand)

Implementation Method Assessed	Reference	Method Number & Shorthand
Ecodesign: A Promising Approach to Sustainable Production & Consumption, The Netherlands	(Brezet and van Hemel, 1997)	1. PROMISE
Life Cycle Design (LCD) Manual for SMEs and Checklist, EU	(Behrendt et al, 1997)	2. SME LCD Manual
Philips Electronics Point of No Return Ecodesign Guidelines and Greening Your Business, The Netherlands	(Philips, 1997) (Philips, 2000)	3. Point of No Return and Greening Your Business
Ecodesign Navigator , UK	(Simon et al, 1998)	4. Ecodesign Navigator
Method for Sustainable Industrial Product Systems, Norway	(Hanssen, 1997)	5. MSIPS
RMIT EcoReDesign™ Guide and Video, Austrialia	(Gertzakis et al, 1997)	6. RMIT
Environmental Assessment of Products: Volume 1: Methodology, Tools, and Case Studies in Product Development, UK	(Wenzel et al, 2000)	7. Environmental Assessment of Products
Design + Environment: A Global Guide to Designing Greener Goods, Australia	(Lewis, 2001)	8. Design + Environment
How to do EcoDesign? A Guide for Environmentally and Economically Sound Design, Germany	(Tischner et al, 2000)	9. How to do EcoDesign
US EPA Life Cycle Design Guidance Manual, USA	(US EPA, 1993)	10. US EPA LCD Manual
Design for Environment Web Guide, Canada	(National Research Council of Canada, 2002)	11. DfE Web Guide
Ecodesign: A training guide for business including Idea! Integrated Design Abacus, UK	(Owen, 2001)	12. Idea

ISO/TR 14062 Integration of Environmental Aspects into Product Design and Development	(ISO, 2002a)	13. ISO/TR 14062
Design of Eco-Efficient Services, The Netherlands	(Brezet et al, 2001)	14. Eco-Efficient Services
Eco Design Guide: Environmentally Improved Product Design Case Studies of the European Electrical and Electronics Industry, EU	(ECOLIFE, 2002)	15. ECOLIFE Guide
Ecodesign - the Electrical and Electronic Practical Eco-design Guide, Spain	(Rodrigo and Castells, 2002)	16. Electrical and Electronic Practical Eco-design
Centre for Sustainable Design CfSD Eco-Design Checklists, UK	(Clark and Charter, 1999)	17. CfSD Ecodesign Checklists
A Designer's Guide to Eco-Conscious Design of Electrical and Electronic Equipment web based guide supported by the Danish EPA, Denmark	(GN- Teknik, 2002)	18. Eco-Conscious Design of EEE
Environmentally orientated product design: A guide for companies in the electrical and electronics industry, Finland	(Kärnä, 2001)	19. Environmentally orientated product design
Standard ECMA - 341, "Environmental design considerations for electronic products"	(ECMA International, 2002)	20. ECMA 341
McDonough Braungart Sustainable Design Protocol & Cradle to Cradle Design™ , Germany and USA	(McDonough and Braungart, 2000)	21. MBDC Cradle to Cradle Design
Method for Sustainable Product Development, Sweden	(Byggeth et al, 2000; Byggeth and Broman , 2000)	22. MSPD

7.3 ASSESSMENT RESULTS

The assessment was an analysis of the existing methods to determine whether or not they met the specified criteria. The researcher reviewed each method in order to conduct the analysis. The assessment matrix in **Table 7.3** illustrates those methods which meet or do not meet the assessment criteria.

The assessment criteria are listed across the top of the matrix using the shorthand previously defined in **Table 7.1 Assessment Criteria and Shorthand used in the Assessment Matrix**.

The twenty two methods assessed are represented by a method number and shorthand (as listed in **Table 7.2**) down the left hand column.

Table 7.3 Assessment Matrix

MATRIX KEY:

■ = the method incorporates the associated criteria. ■ = the method does not incorporate the associated criteria.

	CRITERIA											
METHODS	Simple, flexible, guide	Functionality	Systems	Full Lifecycle	Strategic	Integrated in business systems	Integration of TBL	Business Language	Targeting implementation based on SCD	SCM	Information Supports	Comms, Organisation Management
1. PROMISE		■		■	■	■		■		■	■	■
2. SME LCD Manual		■	■	■		■				■	■	■
3. Point of No Return & Greening Your Business	■				■	■		■		■	■	■
4. Ecodesign Navigator	■					■		■		■	■	■
5. MSIPS		■	■	■	■					■	■	
6. RMIT	■				■	■		■		■	■	■
7. Environmental Assessment of Products						■				■	■	■
8. Design + Environment	■				■	■		■		■	■	■
9. How to do EcoDesign	■	■			■			■		■	■	■

	CRITERIA											
METHODS	Simple, flexible, guide	Functionality	Systems	Full Lifecycle	Strategic	Integrated in business systems	Integration of TBL	Business Language	Targeting implementation based on SCD	SCM	Information Supports	Comms, Organisation Management
10. US EPA LCD Manual						■					■	
11. DfE Web Guide	■	■				■		■			■	
12. Idea	■				■	■		■		■	■	■
13. ISO/TR 14062	■	■	■		■	■		■		■	■	■
14. Eco-Efficient Services	■	■	■	■		■				■	■	■
15. ECOLIFE Guide	■	■	■			■		■		■	■	■
16. Electrical and Electronic Practical Eco-design	■					■		■		■	■	■
17. CfSD Ecodesign Checklists	■				■	■		■		■	■	■
18. Eco-Conscious Design of EEE	■				■	■		■		■	■	■
19. Environmentally orientated product design						■		■			■	
20. ECMA 341						■		■			■	
21. MBDC Cradle to Cradle Design		■		■		■						
22. MSPD					■	■						

The assessment showed that based on the methods assessed, an implementation approach for developing sustainable products and/or services incorporating all the assessment criteria was not currently available for industry. Also, it showed to what extent the methods assessed meet the criteria for effective SPSD implementation and what gaps existed. This helped to identify what new aspects should be incorporated in a new SPSD implementation approach. For each criterion the methods assessed and a summary of the results are in **7.3.1 – 7.3.12.**

7.3.1 Simple, flexible guide

This criterion was incorporated to different extents in the following methods:-

Implementation Method Number and Shorthand	
3	Point of No Return & Greening Your Business
4	Ecodesign Navigator
7	RMIT
8	Design + Environment
9	How to do EcoDesign
11	DfE Web guide
12	Idea
13	ISO/TR 14062
14	Eco-Efficient Services
15	ECOLIFE
16	Electrical and Electronic Practical Eco-design
17	CfSD Eco-Design Checklists
18	Eco Conscious Design of EEE

All of these methods provide an implementation approach supported to varying extents by information, tools and case examples. They all incorporated elements of flexibility, simplicity and customisation to varying extents[4].

Design of Eco-Efficient Services and the *ECOLIFE Guide* specify the requirement for a flexible framework incorporating a range of approaches and tools customised to the offering and organisation culture. The *Design of Eco-Efficient Services* highlights the use of a rigid procedure as a barrier to the dynamic nature and creativity necessary for implementing sustainability in product and service development. Hence *Design of Eco-Efficient Services* itself is a framework implementation guide supported by information, a toolkit and case examples for product and service based organisations. The *ECOLIFE Guide* specifically highlights the necessity for customising integration of environment into product development as this process varies significantly with products and organisations. As such this guide does not see a standard approach as feasible and advocates a customised combination of approaches and tools to meet specific requirements.

Those chosen as simple were seen as pragmatic to use in terms of the format and user friendly nature of the method for industry. User friendly was based on the layout, language, size and supporting information provided. Of the methods meeting this criterion, the following were all identified as meeting this simple, pragmatic criterion to different extents.

- *Point of No Return* and *Greening Your Business*,
- *Ecodesign Navigator*
- *RMIT*
- *Design + Environment*
- *Idea*
- ECOLIFE Guide
- *ISO/TR 14062*

[4] Information on what was incorporated in each of these methods is described in **Appendix 4**.

- *CfSD Eco-Design Checklists*
- *Eco Conscious Design of EEE.*

For example, the *CfSD Eco-Design Checklists* incorporate a one page "Eco-design Healthcheck" questionnaire designed to provide a quick, practical assessment of a companies eco-design performance on a rating from 1 – 5 (poor to excellent).
As already stated, not all the implementation methods assessed were in the format of standalone guides. This included the *MBDC Cradle to Cradle Design*™ (text book and web based guidance), MSPD (published papers) and *MSIPS* (PhD thesis and published papers) and hence these did not meet this criterion.

7.3.2 Functionality

In the main, consideration of the functionality in terms of meeting customer or user requirements is already considered in all approaches assessed. However, considering functionality in this way, as well as in a broader context to meet human needs and assessing a range of options in its provision was less evident. This criterion was incorporated to different extents in the following:-

Implementation Method Number and Shorthand	
1	PROMISE
2	SME LCD Manual
5	MSIPS
9	How to do Ecodesign
11	DfE Web Guide
13	ISO/TR 14062
14	Design of Eco-Efficient Services
15	ECOLIFE Guide
21	MBDC Cradle to Cradle Design

The *PROMISE* approach using the *Ecodesign Strategy Wheel* has "New Concept Development" as the first life cycle category to be considered. In New Concept Development the function required is considered and how to achieve functional optimisation of the product proposed. The *Design of Eco-Efficient Services* method is considered an update and extension of the *PROMISE* implementation approach and is aimed at developing systems of products and services called "Sustainable Satisfaction Delivery Systems" (Brezet et al, 2001, p. 25), which cause minimal environmental impact with a maximum added value. The *Design of Eco-Efficient Services* method reflects the increasing recognition of a role for eco efficient services in the sustainable provision of functions rather than via physical products. It provides an implementation approach for product and service based organisations with the aim of providing *"functions with minimal environmental impact, use of resources and use of space, while creating maximum added value for the different stakeholders"* (Brezet et al, 2001, p. 6). This method highlights that the functional (called Level 3 ecodesign) and system (called Level 4 ecodesign) innovation approaches such as aimed for in *Design for Eco-Efficient Services* are supposed to have the most eco-efficiency potential. An *"idea finding"* phase is part of the implementation process where the focus is on functions and customer demand as distinct from products and translating this functional requirement into concrete Eco-Efficient Service ideas (Brezet et al, 2001, p.15). Information on rethinking the notions of products and services is also included in the method. In the ecodesign introduction of the *ECOLIFE Guide*, the existence of Level 3 ecodesign (described as focusing on a new product conception definition where "*technical functions to fulfill product functionality are different"* creating a new innovative approach (ECOLIFE, 2002, p. 11)) is also included, but little guidance on achieving this level of ecodesign is incorporated in the guide.

The *MSIPS* and *SME LCD Manual* have a strong focus on determining the most environmentally sustainable way to meet functional requirements. *MSIPS* incorporates reducing or modifying the need for a certain function and determining the most efficient way to fulfill the function. Two of the main strategies incorporated in this method to achieve environmental improvements are focused on functionality. These are:-

- ❑ Reformulation of user requirements to determine innovative solutions beyond existing product systems;
- ❑ Improvement in product performance regarding user requirements.

The *SME LCD Manual* implementation process incorporates an *"achieving environmental efficiency/optimal function"* principle which focuses on finding new ways to meet the required customer needs by questioning the functionality required and stretching the boundaries of how it can be provided to include, inter alia, consideration of provision through a service and PSS (Behrendt et al, 1997, p.54).

The *ISO/TR 14062* guidance standard advocates considering the functionality of the product and/or service being designed, as distinct from just providing a "*specific technical solution"* (ISO, 2002a, p. 10). The functionality is described as *"how well the product suits the purpose for which it is intended in terms of usability, useful lifetime, appearance etc."* (ISO, 2002a, p.10). Using a broad approach in determining the options to meet the *"functionality required to fulfill customer or user demands and needs"* is advocated to include consideration of services and PSS combinations (ISO, 2002a, p. 10) with the PSS example of leasing products given. *How to do Ecodesign* advocates a similar approach in defining the scope of the ecodesign process and the idea generation phase of this.

MBDC Cradle to Cradle Design focuses on determining the most eco-effective way to meet a human need and incorporates consideration of services, products and PSS as ways to provide it. This approach sees products as *"packaging for services"* and applies the strategy to *"products of service"* to determine the most effective way to meet a human need (Braungart, 2002, p. 1). Customers buying a service rather than purchasing a product is a key feature of this approach.

7.3.3 Systems

This criterion is incorporated to different extents in the following methods assessed.

Implementation Method Number and Shorthand	
2	SME LCD Manual
6	MSIPS
13	ISO /TR 14062
14	Design of Eco-Efficient Services
15	ECOLIFE Guide

Design of Eco-Efficient Services aims to develop systems of products and services called *"Sustainable Satisfaction Delivery Systems"* made up of the product and/or service and the infrastructural, consumer, institutional context within which it operates (Brezet et al, 2001, p. 25). *Design of Eco-Efficient Services* proposes that the key to a more sustainable result is for designers to look in a holistic and integrative manner for the innovative potential of the process, product or service as well as the infrastructural, consumer and institutional context it operates in. This is described in this framework as the following three aspects:-

- The device/artifact (i.e. innovations to improve the eco-efficiency of the process, product or service);
- The physical and institutional context/infrastructure (innovation in infrastructure/institutions related to using the products and services e.g. leasing instead of purchase and ownership or the new infrastructure required for hydrogen fuelled cars);
- User practice (innovation in user behaviour e.g. a consumer learning to drive and fuel a hydrogen fuelled car).

The remaining methods incorporating systems elements do so to a lesser extent. In determining environmental impact, *SME LCD Manual*, *ISO/TR 14062*, *MSIPS* and the

ECOLIFE Guide include that not only the environmental impact of the product itself should be considered, but its impact on the system in which the product will perform.

7.3.4 Full lifecycle

The functional based approach requires the development of an offering to start by considering the most sustainable way to provide a required functionality to meet a consumer need. This can add in an extra lifecycle stage or step in the offering implementation process not normally considered. This can be called "conception", where concept generation to meet a functionality occurs. Incorporation of this lifecycle stage or step, albeit not necessarily using this name, is advocated in the EPD approaches *Promise*, *Design of Eco-Efficient Services* Method and *SME LCD Manual*. The *Design of Eco-Efficient Services* Method incorporates *"exploration"* and *"idea finding"* steps in the implementation process that considers the most eco-efficient way to provide the function required. Inclusion of these steps is seen as likely to give a more eco efficient result. The *SME LCD Manual* incorporates a *"Product Strategy Stage"* which is an initial stage of product design where the strategy to meet the required needs is addressed (Behrendt et al, 1997, p. 48). At this stage, the first of the thirteen environmental strategies incorporated in this method called *"achieving environmental efficiency/optimal function"* is used (Behrendt et al, 1997, p. 54). This is beyond the remaining twelve environmental optimisation strategies also included in the method as it focuses on finding new ways to meet the required customer needs by questioning the functionality required and stretching the boundaries of how it can be provided. Under this optimal function strategy, a checklist of issues is considered to include:-

- Needs and demands of consumers;
- Dematerialisation through service and PSS options;
- Resource cascading - a method to extend the useful life of a resource by using it repeatedly;
- Performance of the product in the wider system it operates in.

The remaining methods assessed incorporated the lifecycle from raw materials acquisition to end of life such as the life cycle specified in *ISO /TR 14062*. In the main, the focus was on a cradle to grave rather than an explicit cradle to cradle approach. The exceptions to this were the *MBDC Cradle to Cradle Design* approach which is based on a cradle to cradle lifecycle. Two closed loop cradle to cradle life cycles are defined – biological (cycles of nature) and technical (cycles of industry). Using this MBDC method of sustainable design, a products *"biological nutrients"* and *"technical nutrients"* flow in one or the other of these closed loop, cradle to cradle cycles providing *"nourishment"* for something new after each useful life" (McDonough and Braungart, 2002, p. 105, 109). *"Products of consumption"* (McDonough and Braungart, 2002, p. 105) (e.g. biodegradable packaging) are consumed in the biological cycle and should return to the soil safely. *"Products of service"* (McDonough and Braungart, 2002, p. 111) (e.g. electronics goods) circulate in the technical cycle feeding back into industry for reuse.

7.3.5 Strategic

The research had already revealed that most existing EPD methods and tools focus at the operational rather than strategic levels with EPD being incorporated, at best, as part of the product design and development process (Croner, 2000; Charter and Tischner, 2001; Simon et al, 1998) although in some cases not even as part of this (Byggeth et al, 2000; Byggeth and Broman, 2000; Hanssen, 1997) and standard business functions (SustainAbility, 2001). The assessment revealed the following methods advocated incorporating a strategy level commitment for activities relating to reducing the environmental impact of products:-

Implementation Method Number And Shorthand	
1	PROMISE
3	Point of No Return and Greening Your Business
5	MSIPS
6	RMIT

8	Design + Environment
9	How to do Ecodesign
12	Idea
13	ISO /TR 14062
17	CfSD Eco-Design Checklists
18	Eco-Conscious Design of EEE

Also, method 22, *MSPD* advocates a strategy approach in terms of SPD, but in its existing format does not include guidance on how to achieve this.

The *PROMISE* approach provides guidance and a rationale for incorporating ecodesign in the corporate environmental policy as well as providing information on the link between ecodesign and corporate strategy and activities. The follow on *Design of Eco-Efficient Services* incorporates a policy formulation stage in the process to include committing to the end goal of an ecoefficient service within the organisation(s) participating in the development. The *MSIPS* advocates incorporating environmentally sound product development at both a strategic and operational levels.

Point of No Return, *Greening Your Business*, *RMIT*, *Design + Environment* and *ISO/TR 14062* highlight strategic commitment as part of the approach and provide guidance to developing an environmental policy and environmental product policy (as part of an EMS where this is in place). Over time, implementation of ecodesign activities at *Philips* has evolved from an originally *"design focused activity"* to a *"product and design management"* focussed approach, and subsequently to a strategic approach embedded in all levels of the business (Sherwin et al., 2002, p. 2). The use of strategies and strategic plans are identified as success factors in achieving improved sustainability performance of *Philips* products and services (Stevels, 2000).

7.3.6 Integrated in business systems

All the methods assessed incorporate this integration to varying extents. All the methods advocated incorporating EPD or SPD activities, as relevant, into the product design and development process and provided guidance to varying extents on how to achieve this. For example, the *Ecodesign Navigator*, *PROMISE*, *ISO/TR 14062*, *Life Cycle Design*, *ECOLIFE* and *RMIT* methods all provide detailed guidance on integrating EPD activities into product design and development. The *MSPD* advocates integration of SPD with all business systems as a concept and applies SPD within an Integrated Product Development Model already used for product development and incorporates existing product design methods e.g. Concurrent Engineering.

Also, the following methods advocate integration of environment not only in product development but also additional business systems:-

- *PROMISE*;
- *Point of No Return*
- *Greening Your Business*;
- *ISO/TR 14062*;
- *ECOLIFE Guide*;
- *RMIT*;
- *Design + Environment;*
- *MSIPS*
- *Eco-Conscious Design of EEE* .

For example, the *PROMISE* approach highlights the importance of integrating ecodesign in product design and with other business activities e.g. overall environmental management activities, quality, health & safety and logistics management. Regarding EMS, *PROMISE*, *Point of No Return* and *RMIT* methods provide ecodesign guidelines within the structure of an EMS. *MSIPS* is based on the integration of environmental performance, quality and economic issues in the development of products and services. The *ECOLIFE Guide*

encourages integration with the broadest possible business functions on the rationale that incorporating environmental concepts at the earliest stages of concept generation and design is key for environmental and economic benefits as well as ensuring that the scope of sustainability benefits is not limited by decision making in other business functions e.g. planning, finance or marketing, prior to the design process.

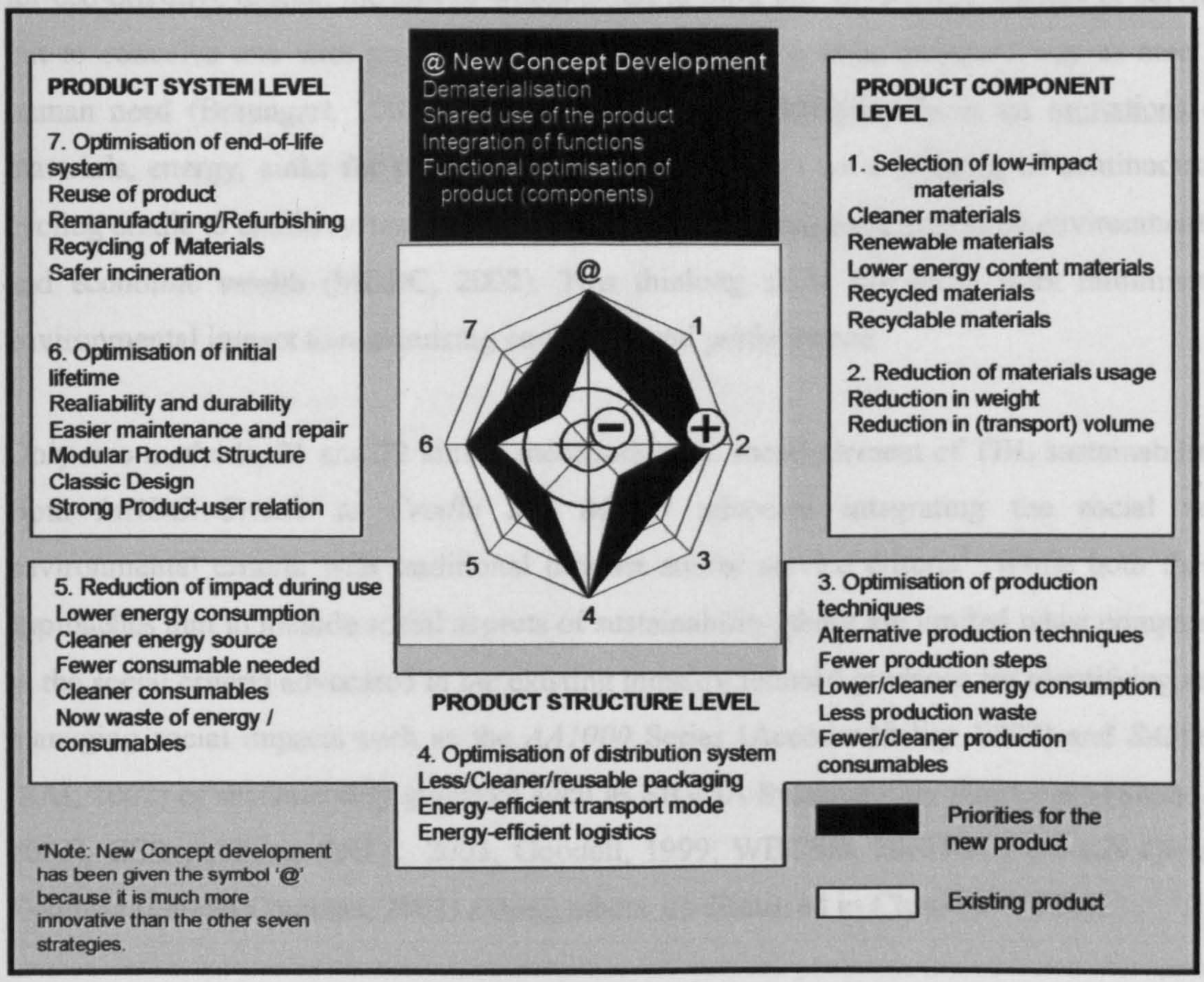
7.3.7 Integration of TBL

The methods coded 1 – 20, as EPD methods, focus on the environmental dimension of sustainability as distinct from a TBL sustainability focus incorporating environment, social and economic issues. While economic and other traditional product criteria are incorporated in some of these methods to different extents, a TBL sustainability focus is not included. These methods focus mainly on ecodesign implementation approaches aimed at optimising the eco-efficiency of products and, in a few cases product and service systems, over a range of lifecycle stages, in particular with respect to the following strategies:-

- Dematerialisation;
- De – energergisation (e.g. de-carbonisation);
- De-toxification;
- Waste prevention and minimisation;
- Prevention and minimisation of pollutant emission to air and water.

Examples of the environmental strategies used are illustrated in the *Ecodesign Strategy Wheel* (ESW) in **Figure 7.1**.as used in *PROMISE* and *SME LCD Manual* (and a range of other methods) and as described in **Appendix 4**.

Figure 7.1 Ecodesign Strategy Wheel (ESW) (Source: reproduced from Brezet et al, 1997, p. 81)



Improving TBL sustainability is not the aim of the EPD methods assessed. While it has been identified that EPD approaches based on environmental optimisation provide incremental environmental and economic benefits and are one part of a solution, this approach on its own is increasingly seen as greening inherently unsustainable systems and inadequate in terms of achieving long term environmental improvement, let alone TBL sustainability (Hanssen, 1999; Hawkens et al, 1999; McDonough and Braungart, 2002; European Foundation, 1997; van Weenan, 1997; Brezet et al , 2001, Roome, 2002; Hart and Milstein, 1999; Simon and Sweatman, 1997; Frei, 1998; Byggeth et al, 2000). In terms of moving beyond an eco-efficiency approach, the *MBDC Cradle to Cradle Design* and

MSIPS advocate eco-effectiveness rather than eco-efficiency – the latter seen as slowing down, but not solving adverse environmental impacts. *MBDC* defines a five step strategy for eco-effective design, the aim of which is not to limit the impact of a product or service but to conceive one with positive impacts and that is the most effective way to meet a human need (Braungart, 2002). This reverses the eco-efficiency focus on limitations of materials, energy, sinks for pollutants etc. and focuses on an abundance of continuously cycling cradle to cradle systems of industrial and natural materials providing environmental and economic wealth (MBDC, 2002). This thinking shifts the focus from minimising environmental impact to maximising environmental performance.

Only two methods, 21 and 22 aim to incorporate the social element of TBL sustainability. Both *MBDC Cradle to Cradle* and *MSPD* advocate integrating the social and environmental criteria with traditional product and/or service criteria[5]. While both these approaches aim to include social aspects of sustainability, these are limited when compared to the social criteria advocated in the existing industry focused guidance for identifying and managing social impacts such as the *AA1000* Series (AccountAbility, 2002) and *SA8000* (SAI, 2002) or sustainability guidance such as SIGMA Sustainability Guidelines (SIGMA, 2003), CSR guidance (BITC, 2003; Goodell, 1999; WBCSD, 2003) and the UN Global Compact (Global Compact, 2002) among others as discussed in **Chapter 4, 4.2.4.**

[5] A description of both is in **Appendix 5**.

While the *MSPD* aims to include social aspects of sustainability based on *The Natural Step* four system conditions, these were identified as limited in terms of the social criteria advocated in the existing guidance discussed in **Chapter 4**. The four system conditions are as follows:-

"For society to be sustainable, the ecosphere must not be systematically subject to:-

1. *Increasing concentrations of substances from the lithosphere;*
2. *Increasing concentrations of substances produced by society;*
3. *impoverishing physical manipulation or over-harvesting, and*
4. *Resources must be used efficiently and fairly to meet basic human needs worldwide"* (Byggeth et al, 2000).

Hence the TBL focus of *MSPD* is limited in terms of the extent of social impacts considered in the development of sustainable products and services. Work is currently underway to incorporate social criteria from these existing social and sustainability approaches into *The Natural Step* itself in order to explicitly include social aspects of sustainability (TNS, 2004; Waage, 2003). The *MBDC Cradle to Cradle* approach proposes that equity (social justice), economy (market viability) and ecology (environmental intelligence) should be optimised in industrial processes, products and services, however, the social criteria to be used are not explicitly specified with the detailed criteria being specified largely for environmental and health and safety related criteria.

Overall, if the aim is TBL sustainability and integrating this with traditional product and/or services criteria, none of the existing implementation methods assessed meet this criteria in full, but have a range of aspects that can be built upon. This is an important gap in the existing implementation methods relevant to developing sustainable products and/or services and will need to addressed in the SPSD approach to be developed.

7.3.8 Business Language

The use of business focused language in the methods assessed varied. A number of the implementation methods which were designed as texts rather than guides e.g. *MBDC Cradle to Cradle*, did not have industry as their key audience by their nature. The following methods were designed as guides for industry and incorporated business language to varying extents.

Implementation Method Number And Shorthand	
1	PROMISE
3	Point of No Return and Greening Your Business
4	Ecodesign Navigator
6	RMIT EcoReDesign
8	Design + Environment
9	How to do EcoDesign
11	DfE web guide
12	Idea
13	ISO /TR 14062

As the above were all designed to be used as implementation guides for incorporating environment into product development, their structure and the language used was aimed at company personnel, in particular, product designers and managers. Also, the language relevant to existing product development processes is incorporated.

The following methods are targeted at the electronics sector and by nature the language used was business orientated and customised to this sector.

Implementation Method Number and Shorthand	
15	ECOLIFE Guide
16	Electrical and Electronic Practical Eco-design
17	CfSD Eco-Design Checklists
18	Eco-Conscious Design of EEE
19	Environmentally orientated product design
20	ECMA - 341

The *Design of Eco-Efficient Services* approach highlights the importance of customising the implementation process to the organisations involved and using appropriate language.

7.3.9 Targeting implementation based on Supply Chain Dynamics (SCD)

The assessment revealed that none of the methods considered the SCD in order to target the most effective organisation for the implementation process in the supply or value chain, based on their control of the offerings conception, design and development lifecycle stages. The application of different elements of the implementation process based on the different roles of supply chain companies was also not considered in this context. While supply chain issues were considered for other reasons (see **7.3.10** and **7.3.12** below), they were not for these purposes. The methods assessed were aimed directly at individual companies irrespective of their role in the supply chain and did not consider the wider product SCD along the offerings supply chain and how this impacted the role for different supply chain players in the implementation process. The methods assessed were focused at implementation in individual organisations rather than across a network of organisations across the supply chain. However, the importance of including the supply chain organisations was highlighted in a number of the methods assessed. For more information

on this aspect see **7.3.10**. Due to the nature of the implementation process in the methods assessed (i.e. being applied to product design and development), it can be said that it is implied that the process is being targeted at the organisation with control of the offerings conception and design, but discussion of this aspect and how it impacts the roles of different supply chain organisations in the implementation process was not incorporated. Some of the methods were aimed at individual companies based on their size (e.g. the *MSPD* and *SME LCD Manual* methods are aimed at engaging and meeting the specific needs of SMEs, but not incorporating their role in the supply chain. Overall, the relevance of an organisation's role in the supply chain in terms of its control of key lifecycle stages and how this impacts its associated activities in the implementation process relevant to developing sustainable offerings was identified as a gap in the existing implementation methods, and would need to incorporated in the SPSD approach as it was identified as a criteriON for effective SPSD implementation.

7.3.10 Supply Chain Management

The following methods assessed advocated effective integration and co-ordination of supply chain organisations in EPD and incorporated guidance for this to varying extents. Also, in order to achieve effective interaction and co-ordination, a team approach incorporating representatives from relevant supply chain organisations was also advocated during EPD implementation in these methods.

Implementation Method Number and Shorthand	
1	PROMISE Manual
2	SME LCD Manual
3	Point of No Return and Greening Your Business
4	Ecodesign Navigator
5	MSIPS
6	RMIT EcoReDesign

7	Environmental Assessment of Products
8	Design + Environment
9	How to do EcoDesign
12	Idea
13	ISO /TR 14062
14	Design of Eco-Efficient Services
15	ECOLIFE Guide
16	Electrical and Electronic Practical Eco-design
17	CfSD Eco-Design Checklists
18	Eco-Conscious Design of EEE

Design of Eco-Efficient Services highlights that implementation across networks of organisations across the supply chain with joint goals is seen as more likely to achieve a more sustainable result and advocates the formation of business coalitions to achieve this. The *ECOLIFE Guide* highlights that effective co-operation, interaction, dialogue and partnerships are necessary to facilitate information transfer. Guidance relating to supply chain management provided in the methods meeting this criterion included the following, to varying extents:-

- Information collection (Life Cycle Data Acquisition (LCDA)) and provision;
- Material procurement;
- Component assembly;
- Recovery, take back, remanufacturing, recycling and disposal;
- Training.

7.3.11 Information supports

The provision of relevant supporting information was a criterion for effective SPSD. A significant number of the methods assessed met this criterion as illustrated in **Table 7.3** Assessment Matrix, with many incorporating a diverse range of relevant supporting

information as part of the implementation guide. A summary of the support information provided in a selection of these methods is below.

- The *PROMISE* approach is a definitive ecodesign guide including background information on the business and environmental case for ecodesign, a seven step ecodesign implementation process with associated modules and work sheets, case examples, information resources, information on support tools e.g. LCA and information on other related topics (e.g. green marketing and resource allocation).
- The SME *LCD Manual* provides background information on the environmental and business case for LCD, guidelines for implementing Life Cycle Design using the LCD Checklists (comprising criteria to consider defined under thirteen environmental principles) and case examples for reducing the environmental impact of product systems.
- *MSIPS* incorporates guidelines, associated tools (including LCA, Life Cycle Costing (LCC) and Quality Function Deployment (QfD)) and case examples for EPD.
- *Ecodesign Navigator* provides a comprehensive ecodesign implementation guide for integrating ecodesign in product development incorporating background information on the business case, strategy formulation, a comprehensive toolbox, case examples, work sheets and a range of information resources.
- The *RMIT Guide* and more recent *Design + Environment* provide background information on the environmental and business case, ecodesign guidelines, an implementation approach, checklists, case examples (documented and on video), information on other related topics (e.g. green marketing and communications) and information resources for EPD with the main focus on redesigning existing products to reduce their environmental impact.
- *Point of No Return* provides ecodesign guidelines within the structure of an EMS to ISO14001and the follow up *Greening Your Business* provides strategic and operational guidelines and tools for ecodesign based on the *Philips* experience. Both provide background information on the business case for ecodesign and information on other related topics e.g. green marketing.

- The *ISO/TR 14062* standard provides summary information on the rationale for integrating environment into product development, specific guidance for strategic, management and product considerations (including mainstream ecodesign strategies to reduce environmental impact).
- The *Design of Eco-Efficient Services* provides a framework implementation approach, toolbox and case examples for product and service based organisations aimed at developing systems of products and services called *"Sustainable Satisfaction Delivery Systems"* (Brezet et al, 2001, p. 25).

The electronics sector EPD implementation guides *ECOLIFE, Electrical and Electronic Practical Eco-design* and, *CfSD Eco-Design Checklists* include an ecodesign implementation approach, strategies, and associated information on concepts and tools e.g. LCA customised to the electronics sector. The first two guides also incorporate electronics case examples. The Standard *ECMA - 341*, specifies requirements, recommendations and a checklist for the design of commercially viable, environmentally conscious ICT and Consumer Electronics products.

The *ECOLIFE* and *Design of Eco-Efficient Services* methods highlight the requirement for dynamic access to information and knowledge in the implementation process. Further, *ECOLIFE* highlights access to ongoing updated knowledge as key to realising continuous improvement as well as ensuring competitive advantage.

7.3.12 Communication, organisation and management

As effective communication, organisation and management internally and across the supply chain were a criterion for effective SPSD implementation, the methods were assessed to see if they incorporated guidance on these issues. The following methods incorporated this guidance to varying extents.

Implementation Method Number and Shorthand	
1	PROMISE
2	SME LCD Manual
3	Point of No Return and Greening Your Business
4	Ecodesign Navigator
6	RMIT
7	Environmental Assessment of Products
8	Design + Environment
9	How to do Ecodesign
12	Idea
13	ISO /TR 14062
14	Design of Eco-Efficient Services
15	ECOLIFE
16	Electrical and Electronic Practical Eco-design
17	CfSD Eco-Design Checklists
18	Eco-Conscious Design of EEE

The communication, organisation and management guidance in these methods included getting management commitment, setting up multidisciplinary, multifunctional teams (internally and across the supply and value chains), allocating roles and responsibilities, supply chain and other organisational partnerships, resource allocation in terms of skills, knowledge, investment and information, training, stakeholder engagement, supply chain management, internal and external communications and green marketing. For example, the

ISO/TR 14062 standard incorporates guidance for strategic (including organisation and communication) and management (including integration with existing management systems, use of multidisciplinary approach, information and data management and supply chain management) considerations (including mainstream ecodesign strategies to reduce environmental impact). Also, the *PROMISE* approach incorporates guidance on organisation, management and communications for ecodesign involving internal and external stakeholders throughout its seven step implementation process. In particular, "Step 1 Organising an Ecodesign project" incorporates guidance on getting management commitment, setting up a project team and establishing plans and budgets. "Step 6 Communicating and Launching the Product" provides guidance on internal and external communication of the product. "Step 7 Establishing follow up activities" incorporates guidance on project and product feedback into the process to include organisation, management and communications. The format of the guide, incorporating modules, tools and work sheets for specific aspects of the implementation process further facilitate the organisation and communication of the process.

7.3 SUMMARY

The assessment of existing approaches against the SPSD criteria showed overall that an implementation method for developing sustainable products and/or services incorporating all the assessment criteria was not currently available for industry. Further, it showed to what extent the methods assessed meet the criteria for effective SPSD implementation and what gaps existed. This helped to identify what new aspects should be incorporated in a new SPSD implementation approach. In particular, none of the methods met the following two criteria:-

- Shifting the focus from a "greening up" environmental focus to a TBL sustainability focus and integrating TBL sustainability criteria with other traditional product and/or service criteria;

- Considering the SCD of the product and/service supply chain to determine the most effective target company (ies) for SPSD implementation (i.e. company (ies) with control of the product and/or service conception, design and development lifecycle stages) and for implementation up and down the supply chain.

The remaining criteria were evident in the methods assessed to varying extents. Those elements of the existing methods incorporating the criteria can be built upon in the new SPSD approach to be developed.

This completes **Phase 2 Development of SPSD Criteria and Assessment** of the research. **Phase 3** of the research to develop, evaluate and finalise the new SPSD implementation approach is described in **Section IV Development and Testing of a New Approach**.

SECTION IV - DEVELOPMENT AND EVALUATION OF A NEW APPROACH

Phase 2 of the research, as described in **Section III** of the thesis, concluded that based on the methods assessed, no mainstream implementation method existed for industry that supported the development of sustainable products and/or services in a true Triple Bottom Line (TBL) context and which met all the specified criteria for effective SPSD implementation. As such, the next stage of the research, **Phase 3 Development and Evaluation of a New Approach** focused on the following objectives:-

- ❑ Develop a new framework approach to support the development of sustainable products and/or services based on the criteria and the results of the assessment;
- ❑ Evaluate the new approach by implementing it on a live case study basis in a representative number of manufacturing industry companies.
- ❑ Based on the case evaluations, revise and finalise the new approach.

This section of the thesis describes Phase 3 of the research and is divided into the following chapters:-

Chapter 8: New Approach – SPSD
Chapter 9: SPSD Case Study Evaluation
Chapter 10: SPSD Guide.

"The world will not evolve past its current state of crisis by using the same thinking that created the situation"
Albert Einstein, 1934

CHAPTER 8 NEW APPROACH - SPSD

8.1 INTRODUCTION

This chapter describes the development and presentation of a new draft SPSD implementation approach for industry to be used as a support in the process of developing sustainable products and/or services. The development of the draft SPSD approach is described in section **8.2**, the key characteristics of the approach are described in **8.3** and the SPSD implementation process in **8.4**.

8.2 DEVELOPMENT OF A NEW APPROACH - SPSD

The approach was developed based on the approaches reviewed (**Chapter** 4), criteria for effective SPSD implementation (**Chapter 6**) and the results of the assessment of existing implementation methods against these criteria (**Chapter 7**). Based on this, the new SPSD approach builds on elements of the existing ones reviewed and incorporates improvements based on the criteria identified to better meet industry requirements and result in the production of offerings with reduced TBL sustainability impacts.

Where criteria are referred to throughout this chapter these relate to the criteria identified for effective SPSD relevant to an implementation process, as described in **Chapter 6, section 6.4**. These criteria were incorporated within the new SPSD implementation approach in order to support effective SPSD implementation. In addition to the criteria, the results of the assessment of existing implementation methods against these criteria were used. The assessment showed that there was no current method that incorporated all

assessment criteria, the extent to which existing methods met the criteria for effective SPSD implementation and the gaps remaining. This helped to identify new aspects that should be incorporated in the new SPSD implementation approach. Those elements of the existing methods incorporating the criteria were built upon in the new SPSD approach developed. The missing elements for each criterion were added to the new method. SPSD is an evolution of the existing approaches as it incorporates all the criteria identified. In so doing, the new draft SPSD approach was designed to meet the requirements of business and industry in developing sustainable products and/or services and to provide formalised support, adding to what is currently available.

8.2.1 SPSD Language and Terminology

Terms and concepts such as Sustainable Product Design and Development (Charter and Tischner, 2001) and Sustainable Product Development (Hanssen, 1997; Byggeth et al, 2000; van Weenan, 1997) already exist[1]. The SPSD approach builds on these existing concepts and SPSD is proposed as a suitable term for practitioners as it clarifies that the approach is applicable to products and/or services. In line with criterion 2 for effective SPSD implementation, SPSD shifts the focus away from producing products to providing a function and determining whether the function can be provided by a service, product or PSS.

It is acknowledged that SPSD is not an easy term for business use as its full title is long and it introduces yet another acronym. For business, it is proposed that the language should focus on sustainable products and/or services or other suitable terminology if already in the company culture, that reflects the same concept. Examples of some terms used by companies identified in the research include innovation, quality and superior products and/or services.

[1] See **Chapter 4**.

8.3 DESCRIPTION OF THE NEW APPROACH - SPSD

Table 8.1 describes the key characteristics of the new draft SPSD approach and includes the definition, aims, intended audience, structure, application and relationship to existing approaches.

Table 8.1	**SPSD Approach definition, aims, intended audience, structure, and application**
Definition	SPSD is the process of developing offerings (products, services or PSS) which are more sustainable in terms of achieving a balance between environmental protection, social equity and economic prosperity throughout their lifecycle, while still meeting other key requirements e.g. quality and technical feasibility (Maxwell and van der Vorst, 2003). In line with criteria 4, 9 and 10, the new draft SPSD approach is designed to provide a framework for implementing SPSD throughout the complete lifecycle of a product and /or service and the associated supply chain. In line with criterion 7, the SPSD process is designed to identify, assess and implement the options for maximising sustainability in offering development while fulfilling traditional criteria.
Aims	The goal of SPSD is to develop offerings, be they products and/or services, that are sustainable (in environmental, social and economic terms), achieve their required functionality and fulfil traditional criteria. The ideal results of the SPSD process are more sustainable products and/or services for the company(ies) involved and reduced sustainability impacts for people and the planet. Hence, the aim of the new SPSD approach is to provide a framework approach that supports effective SPSD implementation in industry to facilitate companies, practitioners and other stakeholders in the development of sustainable offerings.
Intended Audience	The intended audience is industry and practitioners that require guidance in the process of developing sustainable products and/or services. No distinction between offerings for B2B and B2C markets was made. The SPSD approach is applicable to both.

Structure	In line with criterion 1, the approach was developed to be a flexible, generic, qualitative framework of suggested actions for the SPSD implementation process and as such can be applied to any industrial sector. As the process of developing sustainable products and/or services differs not only between sectors, but also between companies, products and /or services, the intention is that it is suitably customised in line with the sector, company, product and/or service requirements. Further, it may be supported by existing tools (e.g. assessment, measurement, benchmarking, reporting, communications) as relevant. The structure of the draft SPSD approach developed and used for the case evaluations incorporated documentation of the implementation process with a range of supporting materials that included training materials (presentations and handouts), supporting tools, information supports (databases and checklists). SPSD expertise in the form of a mentor to facilitate the implementation process was part of the approach for the evaluations. In order to communicate the approach and provide a support for industry in line with criterion 1, post evaluation, the approach was documented as a hardcopy SPSD guide (see **Chapter 10**) with a web-based version planned.
Application	The approach should be used to develop a sustainable offering from its conception onwards or it can be applied to existing products and/or services. However, as greater sustainability benefits are likely if applied at conception (when there is only a functional need to be met and no decision on how it can be provided has yet been made) application from conception onwards is a key part of the process. To start with an existing product and/or service and apply the remaining aspects of the SPSD process can be done, but would miss a crucial stage and potentially significant opportunities for sustainability improvements.
Relationship to existing Sustainability Performance Improvement Approaches	SPSD fits with existing sustainability performance improvement approaches used by industry, as it is designed to be part of a broad Clean Technology (CT) or more accurately "Sustainable Technology" approach since it incorporates all TBL elements. This facilitates its use with widely accepted CT approaches e.g. Environmental Management Systems or future Sustainability Management Systems e.g. the UK SIGMA (Sustainability Integrated Guidelines for Management) (SIGMA, 2003). It extends the environment based CT approach by incorporating all TBL issues (not just environment) and including all life cycle phases (conception to end of life) forming a new element in the CT,

	"Sustainable Technology" and overall SCP approaches. The SPSD process is a key element of CT/Sustainable Technology for product and/or service providers to manage the sustainability impacts of their offerings. In terms of existing methods relevant to developing sustainable products and/or services, namely EPD & SPD approaches, SPSD is an evolution of these methods with respect to all criteria in particular the following:- ❑ Shifts the focus from the provision of products to the provision of functions and considers all options for providing the required functionality, i.e. whether it can be provided by a service, product or some combination of a PSS; ❑ Incorporates all TBL elements (environment, social and economic aspects), shifting the focus from a "greening up" environmental focus to a TBL sustainability focus and integrating TBL sustainability criteria with other traditional product and/or service criteria; ❑ Using the SCD of the product and/or service supply chain to determine the most effective target company(ies) for SPSD implementation (i.e. company with control of the product and/or service conception, design and development lifecycle stages) and for implementation up and down the supply chain.

8.4 SPSD IMPLEMENTATION PROCESS

The stages in the draft SPSD implementation process are based on a modified version of the typical product and/or service development processes used in industry and in particular those advocated in *ISO/TR 14062 Environmental Management – Integrating environmental aspects into product design and development* (ISO, 2002a). These stages are:-

- Planning
- Offering Development (called Product Development in traditional approaches)
  - ⇒ Concept Development
  - ⇒ Detailed Design
  - ⇒ Testing/Prototype
  - ⇒ Offering Launch and Marketing
  - ⇒ Offering Review.

The process is based on this existing structure (albeit modified) to facilitate understanding and implementation of SPSD in existing product and/or service development processes. However, the elements within these stages incorporate the additional elements identified as necessary for developing a sustainable product and/or service based on the SPSD effectiveness criteria and the assessment of existing methods. A Planning stage is incorporated in *ISO/TR 14062* and a number of the existing implementation approaches reviewed. Instead of "Product Development", "Offering Development" is the second stage of SPSD to reflect that an offering which could be a service, product or PSS may be developed. Each of the stages of the SPSD implementation process is summarised in **8.4.1 – 8.4.2**. These include how each stage incorporates the additional elements. The stages can be iterative and are designed to provide a flexible framework of suggested actions in order to develop sustainable products and/or services effectively.

The following support materials are also used in the process:-

- Introductory Information Module
- SPSD Sustainability Assessment Checklist
- Ongoing Information Supports
  - ⇒ Sustainable Products and/or Services Database of information resources
  - ⇒ Legislative compliance obligations
  - ⇒ Industry schemes, voluntary standards and labeling specifications
  - ⇒ Information from supply chain companies e.g. data on raw materials, components, assemblies etc…
  - ⇒ Data on alternatives (e.g. materials, energy sources) from existing data sources e.g. suppliers and databases.
- Support tools.

These support materials are described in the relevant sections below based on which stages of the process they are used in. An outline of the content of the draft SPSD implementation process stages is in the **Figure 8.1**.

Figure 8.1 Draft SPSD Implementation Process Stages

PLANNING

1 Organisation, Management & Communication

2 Provision of Introductory & Ongoing Information

3 Strategic commitment and integration into existing business systems

OFFERING DEVELOPMENT

1 Concept Development

- Functionality
  - ⇒ Starting with the function to be provided;
  - ⇒ Considering all the options for meeting the functionality – services, products and PSS;
  - ⇒ Considering the wider systems interactions;
- Determine life cycle stages;
- Assessing the sustainability impacts;
  - ⇒ Integrating TBL sustainability criteria with traditional product and/or service criteria;
- Determine the Supply Chain Dynamics
  - ⇒ Determine optimum target for SPSD and other roles;
  - ⇒ Supply Chain Interaction and Co-ordination (Supply Chain Management);
- Full Sustainability Assessment.

2 Detailed Design
3 Testing/Prototype
4 Production
5 Offering Launch and Marketing
6 Offering Review

8.4.1 Planning

8.4.1.1 Provision of introductory supporting information

Once a company commits to developing sustainable products and/or services (whatever their language for this concept), the first step in the SPSD process is to provide relevant supporting information to ensure all parties have a comprehensive understanding of the background information. This incorporates criterion 11. This information is customised to suit the situation e.g. sector, company (ies), existing or likely product and/or service as well as existing knowledge base of the company(ies) involved. The content of the supporting information (introductory and ongoing) was based on the information criteria identified previously for the SPSD effectiveness criteria[2]. Information and knowledge relating to the business case, assessing the environmental, social and economic impact of products and services, compliance requirements, technical specifications from suppliers and customers, technical innovations and market developments were all specified as key information requirements. A number of the implementation methods assessed included a diverse range of supporting information and this was used as a basis to determine suitable introductory and supporting information[3]. The introductory supporting information covers the following issues:-

- Why develop sustainable products and/or services?
- What is the end result and benefit of developing sustainable products and/or services?
- Business Case
- Legal and Market Drivers
- What is SPSD?
- How does SPSD fit within existing sustainability, environmental, product and/or service development and other business systems?
- Information resources

[2] See **Chapter 6**, sections **6.3.11** and **6.3.13**.
[3] See **Chapter 7**, section **7.3.11**.

- Introduction to the Sustainable Products and/or Services Database of information resources

An introductory information module is presented to company(ies) to include, as a minimum, information on the following:-

- the business case for developing sustainable products and/or services,
  - ⇒ legal and market drivers relevant to their situation,
    - compliance requirements,
    - standards,
  - ⇒ expected outcome and business benefits,
- a description of the SPSD process,
- potential pitfalls
- innovative case examples relevant to the situation.

The information module is to inform, as well as inspire companies with innovative case examples. The audience for the information should be as representative as possible, ideally incorporating the most senior representative (e.g. CEO), senior management and representatives from all business functions/units within the initiating company. Once the stakeholders in the offering development team are identified[4], a similar information provision session should be given to this team.

The introductory supporting information is provided in the process documentation and as a series of presentations. The presentations can be given by the project champion and/or SPSD mentor if they have the appropriate expertise, or by a third party as required[5]. For the purposes of the evaluation of the approach[6], the SPSD mentor and external environmental consultants provided the introductory information session (s).

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[4] For further guidance on this see section **8.4.1.3** below.
[5] For further information on the project champion and mentor see **8.4.1.3**.
[6] See **chapter 9**.

In line with the identified requirement for dynamic access to information and knowledge via a range of internal and external stakeholders (Ecolife, 2002; European Foundation, 1997a; Brezet et al, 2001; Nielsen et al, 2002; Hanssen, 1997; Charter, 2001), a web based version of the SPSD approach, which could incorporate updated information supports more effectively than a text based version, is proposed as a future medium for the SPSD approach.

8.4.1.2 Incorporating a strategic level commitment and integration into existing business systems

The next stage is to make a commitment to developing sustainable products and/or services at the most senior level and integrate it into the business goals. This stage incorporates criteria 5 and 6. The commitment is to conduct activities and provide offerings (e.g. services, products or PSS) that are environmentally sound, socially responsible, economically feasible and meet other relevant product and/or service criteria. The commitment is to be made by the companies taking responsibility for the SPSD implementation and can be via the corporate strategy or equivalent dependant on the company culture. From the strategic level the commitment should be integrated into other business systems. **Figure 8.2** illustrates a proposed structure for this integration.

Figure 8.2 Integrating SPSD into corporate systems



The requirement to conduct the company activities in a sustainable manner and provide sustainable products and/or services, is one element of the existing corporate strategy (illustrated in the central sphere). From there it is a core business criterion that can be incorporated into all other business functions (e.g. finance, marketing, quality, production, environment (and social management if it exists) health & safety, purchasing) for overall sustainability performance improvement. In particular, SPSD should be incorporated within the offering (product, service or PSS) design and development approaches used by the company (Simon et al, 1998; Brezet and van Hemel, 1997; ISO, 2002a; Behrendt et al, 1997; ECOLIFE, 2002; Gertzakis et al, 1997; Lewis, 2001) as well as wider business systems (Frei, 1998; Stevels, 2000; Neilsen et al, 2002; Mont, 2001; Byggeth and Broman, 2000; Hanssen, 1997; ; Brezet and van Hemel, 1997; ISO, 2002a; Behrendt et al, 1997;

ECOLIFE, 2002; Gertzakis et al, 1997; Lewis, 2001; Philips, 1997; Philips, 2000a). Other functions that traditionally feed into product and/or service development e.g. quality, finance and purchasing, will then be incorporated more easily with the sustainability criteria. Further, where a company operates a system to manage their environmental (and where included wider social) performance e.g. EMS, SPSD should be imbedded within it. A commitment to developing sustainable offerings can be made in the Sustainability Management Strategy (where this exists), but more likely in the EMS Environmental Policy Statement followed up with specific Environmental Objectives and Targets that relate to developing sustainable products and services. This goes beyond incorporating a strategic commitment into the Environmental Policy alone as advocated in the majority of methods assessed that incorporated a strategic commitment[7]. Integration of SPSD in these existing systems is to achieve an operational framework to build on the strategic commitment. In line with the *Philips* experience (who evolved their ecodesign activities from a design focused to strategic approach embedded in all levels of the business (Sherwin et al., 2002)), incorporating a commitment to developing sustainable offerings in the strategic plan is noted as a success factor in achieving improved sustainability performance (Stevels, 2000). Overall, by integrating sustainability in the corporate strategy and business functions it is a core element necessary for improving business performance rather than a stand-alone programme.

8.4.1.3 Organisation, Management and Communications

To meet criterion 12, recommended actions for initial and ongoing organisation, management and communication to facilitate SPSD, both internally and across the supply chain, are incorporated in the implementation process. The recommendations on communication, organisation and management in the methods assessed meeting this criterion were used as a basis for developing this step[8]. This included guidance on getting management commitment, setting up multidisciplinary, multifunctional teams (internally

[7] See **Chapter 7, 7.3.5.**
[8] See **Chapter 7, 7.3.12.**

and across the supply and value chains), allocating roles and responsibilities, supply chain and other organisational partnerships, resource allocation in terms of skills, knowledge, investment and information, training, stakeholder engagement, supply chain management, internal and external communications. The suggested actions for this step include:-

- Scoping meetings within the initiating company(ies) to discuss the proposed offering development. This should include identification and accessing of required information, developing objectives, a plan, allocating budgets/costs and identifying development team members.

- As in the *Design of Eco-Efficient Services* method, a requirement for an initiator in the form of an organisation, company and internal champion (Brezet et al, 2001) was incorporated. One company in the supply chain (typically the company with control over the conception and design of the offering in question) takes overall responsibility for the offering's development. Responsibility for specific elements of the process may be allocated to supply chain companies. An overall champion/project manager for the complete SPSD implementation process should be allocated within the company taking overall responsibility. Ideally this individual will be from a sustainability related (where this exists), environmental, product and/or service development function within the existing company structure. Where this person has expertise relevant to developing sustainable products and/or services, they can be the mentor who facilitates and guides the SPSD implementation process. If not, a mentor with this expertise is advised as part of the process. Where internal expertise is not available, external expertise can be used for the mentor role as long as externals work closely with the project champion and team to transfer expertise into the company(ies) involved to enable ongoing SPSD activities.

- Once the company taking overall responsibility is determined, a meeting(s) with the CEO and senior management of this company should take place to provide suitable

introductory information and agree the strategy level commitment to developing sustainable products and/or services.

- All stakeholders relevant to the offering development should be identified and incorporated in the development team to ensure multidisciplinary cross functional teams representing the different business functions internally and across the supply chain (Hanssen, 1997; ISO, 2002a; Brezet and van Hemel, 1997; ECOLIFE, 2002; Simonsson and Barthel, 2002; Charter, 2001; Stevels, 2000). Suggested stakeholders for the development team include:-

  ⇒ representatives from each key business function (i.e. product design and development, environment, quality, health and safety, purchasing, finance, marketing) in the company taking overall responsibility for the SPSD implementation,

  ⇒ suitable representatives from supply chain companies,

  ⇒ Business to Business (B2B) customers;

  ⇒ external expertise (i.e. SPSD and industry expertise relevant to the offering being developed).

- Identification, engagement and effective management of stakeholders at an early stage in the offering's development are key elements of SPSD. The timing of this is dependant on identifying all the relevant stakeholders and may vary depending on the situation. For example, if there is an existing product and/or service some of the likely stakeholders will be identifiable e.g. customer(s) and supply chain companies. If it is a new offering, the stakeholders will need to be identified. Stakeholders may also be identified at different stages in the process and should be incorporated when required.

- Once the key project team members are identified, an initial meeting(s) should be held with the entire team to communicate the aims, deliverables, plan, team members and their roles. The introductory information module should be included in this session. This meeting should include the CEO/senior management representative, and illustrate

the strategy level business commitment to the development of a sustainable offering. The aim of this initial meeting(s) is to communicate information, inspire, identify potential problems, illustrate commitment from the top and get buy in from the participants early on.

- In the offering development stage, the development team should be involved at all stages of concept development to provide all the multidisciplinary input required to identify the most sustainable offering which meets all requirements. From detailed design onwards the members of the development team can be included on an as needs be basis.

- As the offering development stages can be iterative, regular status meetings with the development team are advised to discuss progress and, in particular, changes in direction and potentially the need to rethink previously identified options.

- The offering review stage (as advocated in *ISO/TR14062* and *PROMISE*), should incorporate the entire development team to provide feedback on the development process, sustainability and other business impacts of the final offering and experiences which can be used to improve future offerings and/or the development process (ISO, 2002a; Brezet and van Hemel, 1997).

8.4.2 Offering Development

With planning complete, the offering development is the next phase in the SPSD implementation. The offering development process incorporates the following stages:-

- Concept Development
- Detailed Design
- Testing/Prototype
- Offering Launch and Marketing

- Offering Review.

These are described in **8.4.2.1 - 8.4.2.4.**

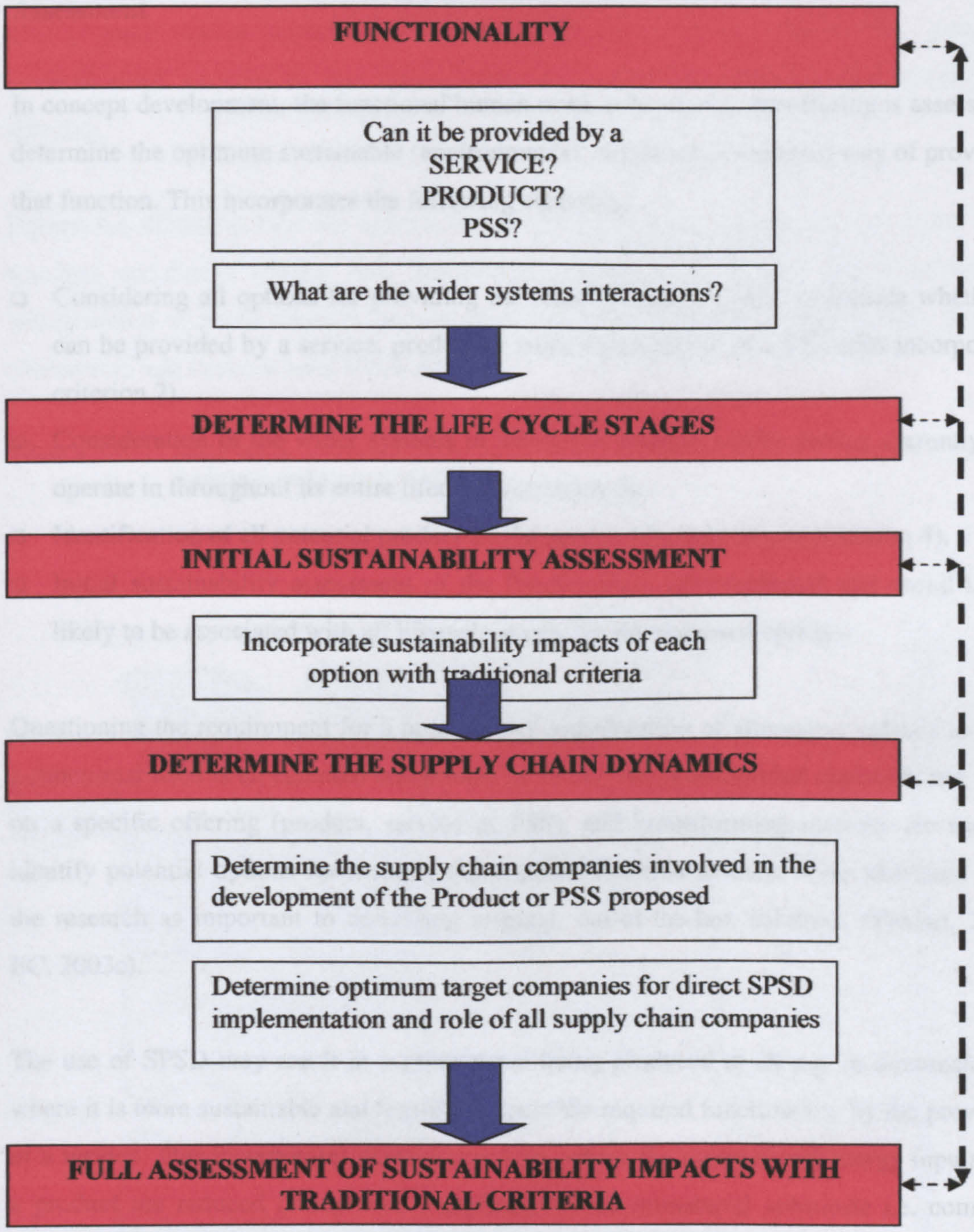
8.4.2.1 Concept Development

The concept development stage incorporates a number of the criteria identified for effective SPSD implementation. The main elements include the following:-

- Functionality
  - ⇒ Starting with the function to be provided;
  - ⇒ Considering all the options for meeting the functionality – services, products and PSS;
  - ⇒ Considering the wider systems interactions;
- Determine life cycle stages;
- Assessing the initial TBL sustainability impacts;
  - ⇒ Integrating TBL sustainability criteria with traditional product and/or service criteria;
- Determine the Supply Chain Dynamics
  - ⇒ Determine optimum target for SPSD and roles of supply chain companies;
  - ⇒ Supply Chain Interaction and Co-ordination (Supply Chain Management);
- Full Sustainability Assessment.

The key steps in Concept Development are illustrated in **Figure 8.3** and should be referred to throughout the description of these steps below. These elements are incorporated in these steps. These are iterative elements as illustrated by the dashed lines.

Figure 8.3 SPSD Process – Concept Development Stage



8.4.2.1.1 Functionality, Systems, Determine Life Cycle Stages, Initial Sustainability Assessment

In concept development, the functional human need to be met by the offering is assessed to determine the optimum sustainable (environmental, social and economic) way of providing that function. This incorporates the following elements:-

- Considering all options for providing the required functionality, to include whether it can be provided by a service, product or some combination of a PSS (this incorporates criterion 2).
- Consideration of the wider systems in which the product and/or service currently/will operate in throughout its entire lifecycle (criterion 3).
- Identification of all potential product and/or service lifecycle stages (criterion 4).
- Initial sustainability assessment of the functionality, environmental and social issues likely to be associated with all lifecycle stages for the proposed options.

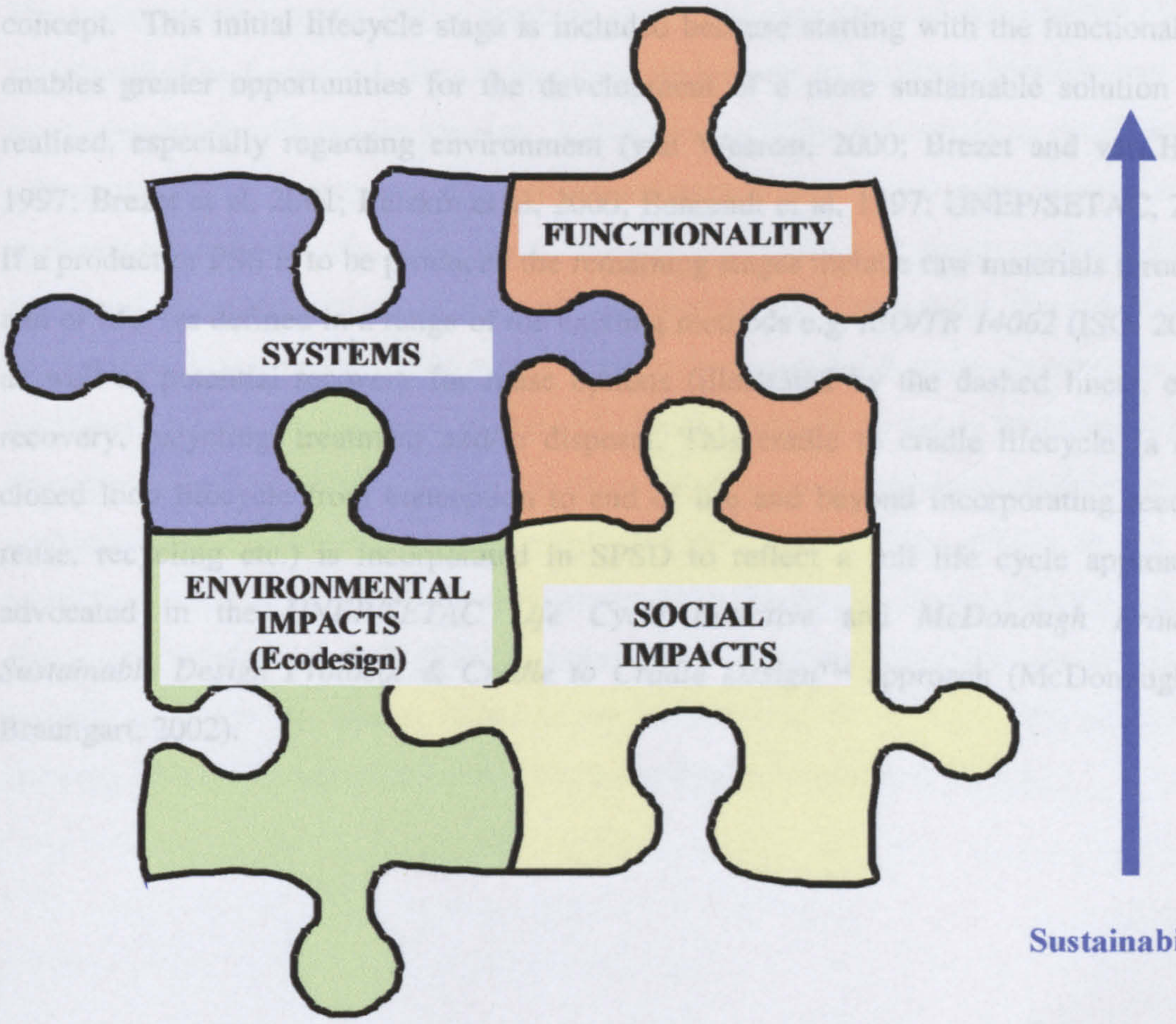
Questioning the requirement for a product and consideration of alternative options to meet a functional need is an essential component of SPSD. An open-minded approach, not fixed on a specific offering (product, service or PSS), and brainstorming sessions are used to identify potential options for meeting the required function as these were identified from the research as important to delivering original, out-of-the-box solutions (Tukker, 2003; EC, 2003c).

The use of SPSD may result in a product not being produced at all e.g. in circumstances where it is more sustainable and feasible to meet the required functionality by the provision of a service. This incorporates dematerialisation, where the material and energy inputs into a product are reduced or replaced completely by an immaterial substitute i.e. complete dematerialisation (van Hemel, 1998). In reality, it is difficult to achieve complete dematerialisation and still achieve the functional need. However, a combination of a product and service approach that reduces the product element is a more likely possibility

(van Hemel, 1998). It should be noted that adverse social impacts may be associated with the replacement of a product by a service where this is feasible (e.g. unemployment). In SPSD, these social impacts are incorporated and assessed against the potential environmental benefits in the sustainability assessment to ensure a TBL sustainable offering.

Figure 8.4 illustrates how the options for sustainability are increased as one moves from standard eco-design criteria that incorporate environmental impacts alone through to incorporation of social impacts, provision of functionality to meet human needs through alternatives and systems level interactions.

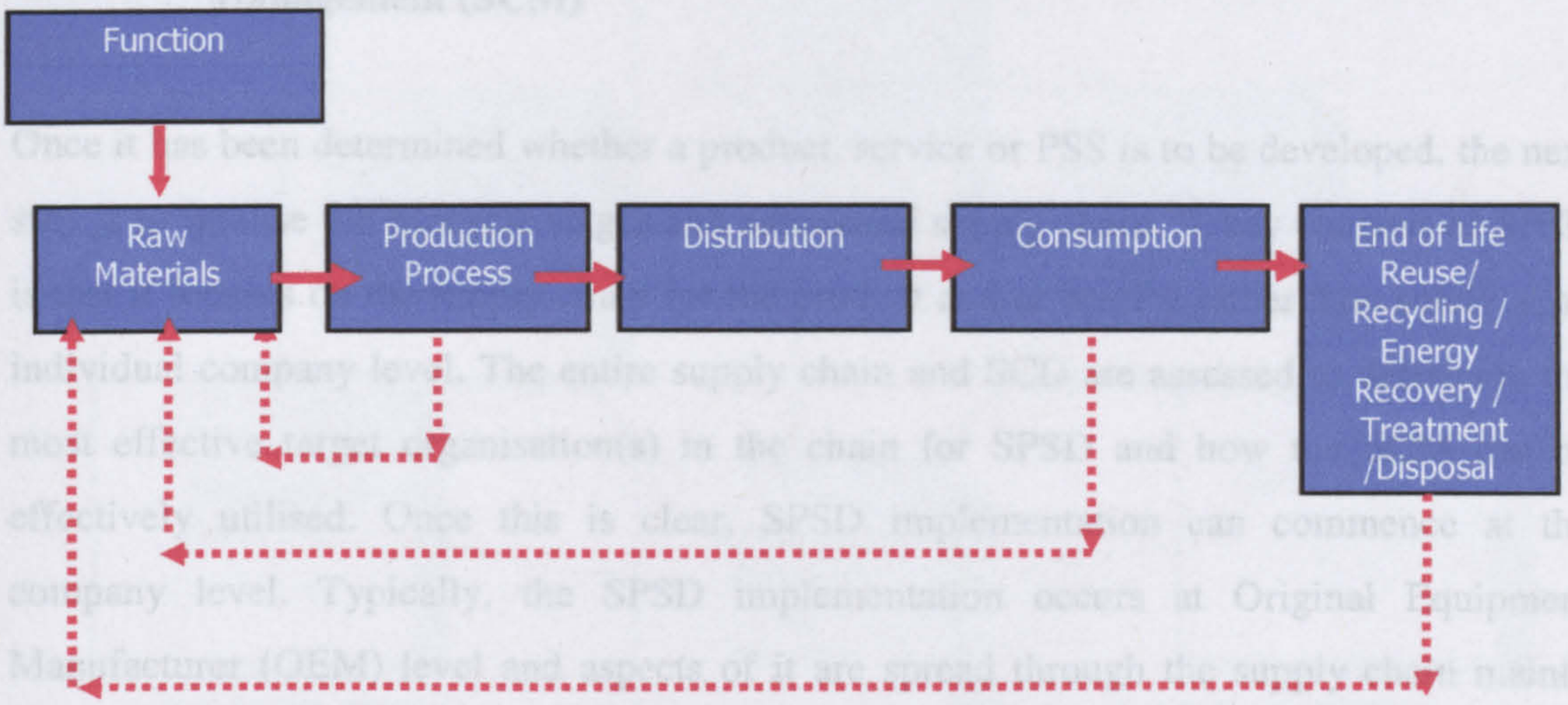
Figure 8.4 Increased sustainability from consideration of environment, social, systems and functionality



In conducting the initial sustainability assessment, the entire system in which the offering operates, to include the institutional, infrastructural, network and consumer context, should be incorporated in the process as this was identified from the research into this criterion and the methods assessed as important to achieving sustainability improvements (Brezet et al, 2001; European Foundation, 1997; Mont, 2002; Behrendt et al, 1997; ISO, 2002a; Hanssen, 1999; ECOLIFE, 2002).

As discussed above, SPSD is about assessing the lifecycle of a function and determining the most sustainable (environmental, social and economic) way of providing that function (through a product, service or PSS) in line with traditional product and/or service criteria. For a product or PSS, the lifecycle is illustrated diagrammatically in **Figure 8.5.** This incorporates criterion 4. This lifecycle starts with a functional need, where there is only a concept. This initial lifecycle stage is included because starting with the functional need enables greater opportunities for the development of a more sustainable solution to be realised, especially regarding environment (van Weenan, 2000; Brezet and van Hemel, 1997; Brezet et al, 2001; Reiskin et al, 2000; Behrendt et al, 1997; UNEP/SETAC, 2002). If a product or PSS is to be produced the remaining stages include raw materials through to end of life, (as defined in a range of the existing methods e.g. *ISO/TR 14062* (ISO, 2002a)) as well as potential recovery for reuse options (illustrated by the dashed lines), energy recovery, recycling, treatment and/or disposal. This cradle to cradle lifecycle (a cyclic closed loop lifecycle from conception to end of life and beyond incorporating recovery, reuse, recycling etc.) is incorporated in SPSD to reflect a full life cycle approach as advocated in the *UNEP/SETAC Life Cycle Initiative* and *McDonough Braungart Sustainable Design Protocol & Cradle to Cradle Design*™ approach (McDonough and Braungart, 2002).

Figure 8.5 Product and PSS Life Cycle Stages



The sustainability impacts (environmental, social and economic) of the potential offerings are identified and assessed. This is an initial assessment to facilitate identification of the most sustainable offering to develop. A full sustainability assessment is conducted as a subsequent step in the process. The initial assessment is limited to consideration of only the environmental (as identified from the research into the *Philips* ecodesign approach (Stevels, 2000) and social impacts associated with provision of the functionality. The aim is to meet the functional requirement while maximising environmental and social performance. Other traditional criteria are excluded in this initial assessment so as not to limit creativity and identification of all options which maximise environmental and social performance. The traditional criteria are then incorporated with the sustainability criteria in the initial assessment of these options. This will narrow down the options for the offering that meets the criteria required. A draft SPSD Sustainability Assessment Checklist was developed to provide guidance on typical issues to be incorporated in assessing the sustainability impacts. This is in Appendix 7 and is discussed further in section 8.4.2.1.3.

8.4.2.1.2 Determine Supply Chain Dynamics (SCD) and Engage Supply Chain Management (SCM)

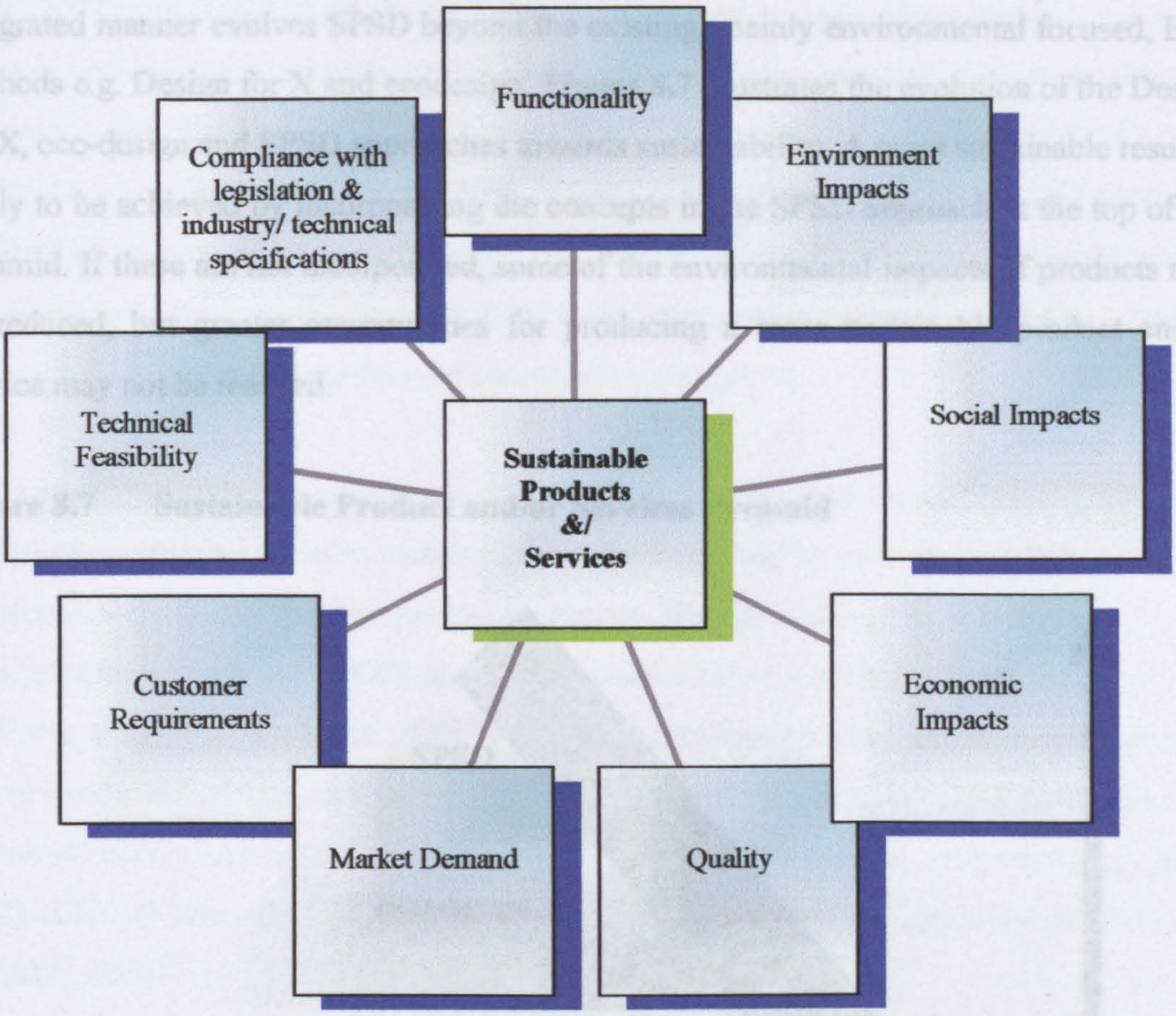
Once it has been determined whether a product, service or PSS is to be developed, the next step is to finalise the lifecycle stages and associated supply chain. A key element of SPSD is that it focuses on the supply chain for the product and/or service rather than solely at an individual company level. The entire supply chain and SCD are assessed to determine the most effective target organisation(s) in the chain for SPSD and how the SCM can be effectively utilised. Once this is clear, SPSD implementation can commence at the company level. Typically, the SPSD implementation occurs at Original Equipment Manufacturer (OEM) level and aspects of it are spread through the supply chain mainly through changes in the product and/or service specification. Full SPSD implementation is typically not required by all supply chain companies, just the one(s) with control over the main life cycle phases that have key sustainability issues. However, the integration and co-ordination of all relevant supply chain companies into the process (even if only on an information supply basis) is crucial. This aspect of the implementation process incorporates criteria 9 and 10.

8.4.2.1.3 Full Sustainability Assessment

The next step is to fully assess the environmental and social impacts for each life cycle stage of the proposed offering (product, service or PSS) e.g. raw materials to end of life and beyond. The opportunities for elimination or minimization of these are integrated with the remaining traditional product and/or service criteria.

To effectively integrate sustainability in product and/or service development, SPSD integrates sustainability criteria with traditional product criteria. This incorporates criterion 7. An illustration of the proposed criteria to be incorporated in developing sustainable products and/or services is provided in **Figure 8.6**

Figure 8.6 Critera for Developing Sustainable Products and Services



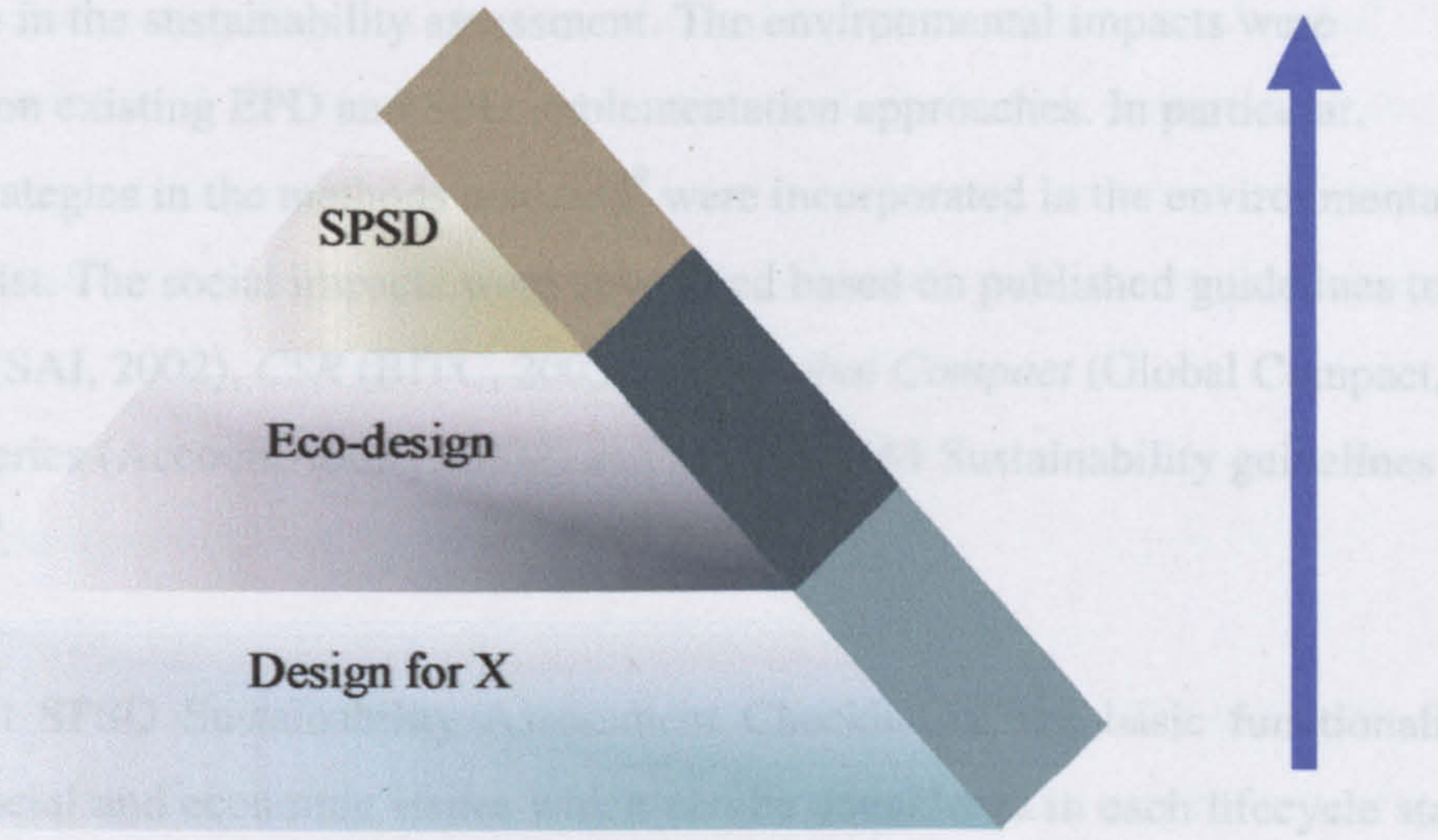
In addition to the traditional product criteria e.g. economic, quality, market, customer requirements, technical feasibility and compliance issues illustrated in **Figure 8.6**, the following sustainability criteria are incorporated in SPSD:

- Environmental impacts;
- Social impacts.

The third TBL element, economic impacts, is already a criterion. Also, functionality is included. This relates to assessing the functionality required and the options for realising this through a product, a service or a PSS, as already discussed.

The incorporation of social with environmental, economic and functionality issues in this integrated manner evolves SPSD beyond the existing, mainly environmental focused, EPD methods e.g. Design for X and ecodesign. **Figure 8.7** illustrates the evolution of the Design for X, eco-design and SPSD approaches towards sustainability. A more sustainable result is likely to be achieved by incorporating the concepts in the SPSD approach at the top of the pyramid. If these are not incorporated, some of the environmental impacts of products may be reduced, but greater opportunities for producing a more sustainable product and/or service may not be realised.

Figure 8.7 Sustainable Product and/or Services Pyramid



In the sustainability assessment, the environmental and social issues to be assessed vary depending on the offering involved. In line with current practice recommended by *UNEP/SETAC* under the *Life Cycle Initiative* and the *EC* under *IPP*, Life Cycle Thinking is used to identify and evaluate the environmental and social impacts for each lifecycle phase (UNEP/SETAC, 2002; EC, 2003). As discussed in **Chapter 4**, traditionally, Life Cycle Thinking addresses environmental problems from a systems or holistic perspective with the

goal of optimising environmental performance over the entire product lifecycle (Fava and Saur, 2002). In SPSD, Life Cycle Thinking is applied to both environmental and social impacts and is used to identify and assess the sustainability impacts associated with each lifecycle stage. It is not Life Cycle Assessment (LCA) as defined in *ISO140040* (ISO, 1998) but a simplified, more qualitative, flexible assessment. Life Cycle Thinking provides a qualified assessment of the environmental and social impacts. This may be sufficient for the assessment and can also be supported by suitable quantitative tools e.g. LCA, abridged LCA and others where more detailed information is required.

To ensure a comprehensive approach, a draft **SPSD Sustainability Assessment Checklist** of typical environmental and social impacts to be considered in each lifecycle stage was developed for use in the sustainability assessment. The environmental impacts were developed based on existing EPD and SPD implementation approaches. In particular, environmental strategies in the methods assessed[9] were incorporated in the environmental part of the checklist. The social impacts were developed based on published guidelines to include *SA 8000* (SAI, 2002), *CSR* (BITC, 2003), *UN Global Compact* (Global Compact, 2002), *AA1000* Series (AccountAbility, 2002) and draft *SIGMA* Sustainability guidelines (SIGMA, 2003)[10].

An example draft SPSD Sustainability Assessment Checklist of the basic functionality, environmental, social and economic issues which can be considered in each lifecycle stage in the SPSD process is in **Appendix 7**. Examples of typical issues related to traditional product criteria e.g. market, technical, legal and quality are also included. The checklist is a guide to the TBL issues that should be considered in the development of a sustainable product and/or service. This checklist provides generic examples that are suitably customised in each situation e.g. dependent on the sector, product and/or service and companies involved. Examples of additions to the checklist are technical specifications,

[9] See **Chapter 7, 7.3.7.**
[10] See **Chapter 4.**

WEEE and RoHS compliance obligations (e.g. for electronics goods), specifications for environmental declarations e.g. *Energy Star* (for electronics goods).

On completion of the full sustainability assessment, the sustainability impacts associated with each offering option are identified and evaluated. The offering that best meets the product and/or service criteria (sustainability plus more traditional criteria) can then be finalised. If required, decision support tools e.g. matrices may be used to facilitate the final decision making process. The final offering option(s) can then be consolidated into specifications as per normal product development practice.

Of all the stages in the SPSD approach, the Planning and Offering Development stages present the greatest differences in comparison to traditional product development and incorporate new elements. For this reason, their description has been detailed. The remaining stages, detailed design through to offering launch and review are already included in typical product development processes and while they have been modified to incorporate the criteria for effective SPSD implementation, they do not require as much explanation.

8.4.2.2 Detailed Design and Testing/Prototype

Once the offering (product, service and/or PSS) to be developed is identified in the Concept Development phase, detailed design and testing/prototype development commences. This is in line with normal product development processes. Based on the detailed design and prototype development and testing phases, the offering specification can be finalised. Further concept development activities may be required if detailed design or testing flag problems (either with traditional or sustainability criteria) with the offering.

The development of prototypes and testing against the required offering specification in terms of environmental, social and all other criteria is conducted in this stage. This can encompass a range of offering elements (e.g. components) as well as the total offering and the overall offering process. All aspects of the product, service or PSS under development

should be tested. Testing should encompass all offering specification requirements to incorporate the following:-

- Functionality
- Quality
- Technical (e.g. material properties, durability, lifetime, manufacturability, disassembly, reuse)
- compliance with relevant policy/regulatory requirements (environmental, health & safety, industry specific etc.);
- compliance with relevant industry/technical specifications e.g. CE marking;
- third party product validation options i.e. Environmental Product Declarations (e.g. eco labels);
- Environmental
- Social
- Economic.

Testing of service elements can be against the expected outcomes defined in the service specification. Based on the testing results, changes required to the offering design should be identified, implemented (by revisiting earlier offering development stages as required) and the offering specification finalised.

8.4.2.3 Production

Based on the specification, as relevant, production can commence. For a new offering, the infrastructure to provide the product, service or PSS may need to be set up. Once initial production has commenced, the sustainability impacts should be reassessed against the original sustainability impacts to determine if any additional unforeseen impacts to the specification arise from mainstream production. Rework and revisiting of earlier steps in the development process may be required if this is the case.

8.4.2.4 Offering Launch and Marketing

As relevant, information appropriate for the consumption and end of life phases of the offerings lifecycle should be determined and communicated. This information should have been identified in the sustainability assessment. Based on the information, appropriate communication methods should be developed. Examples could include customer information advising on best use (e.g. energy efficiency), leasing arrangements, upgrade or end of life service arrangements. On the marketing front, the marketing benefits of the sustainability aspects of the offering should be determined, as relevant. Examples include third party declarations e.g. *Energy Star* or the *EU Eco label* that demonstrate environmental benefits or *Fair Trade* that focus on social issues to a predefined specification. Accreditation to these schemes may be obtained and used for the marketing of the sustainability benefits. All environmental and social information to be used in a marketing context should be backed up with the appropriate proof that these criteria are met in reality. The specifications defined in relevant third party declarations or standards should be used for clearly specifying this information.

8.4.2.5 Offering Review

The entire development team is brought together for the offering review to discuss feedback on the following:-

- the development process,
- the sustainability and other business impacts of the final offering,
- evaluation of whether the final offering met the full specification requirements;
- feedback from stakeholders in particular customers;
- experiences learnt which can be used to improve future offerings and/or the development process.

The results of the feedback should be incorporated into the offering development process and into future offerings developed.

8.4.3 Information Supports – Ongoing

Information supports are used on an ongoing basis throughout the SPSD implementation process. These supports are customised to suit the situation (e.g. company(ies), sector, product and/or service involved) and may include:-

1. General information resources e.g. the Sustainable Products and/or Services Database developed for the SPSD approach[11];
2. Legislative compliance obligations;
3. Industry schemes, voluntary standards and eco labeling specifications;
4. Information from supply chain companies e.g. data on raw materials, components and assemblies;
5. Data on alternatives (e.g. materials, energy sources) from existing data sources e.g. suppliers and databases;
6. Support tools.

8.6 SUMMARY

The development and draft SPSD implementation process was described in this chapter. This was subsequently evaluated by implementing the process in a representative group of companies as described in **Chapter 9**.

[11] This is a database of information resources designed to provide a key information support to the SPSD implementation process. This is included in Part IV of the SPSD Guide (on CD ROM) attached to **Chapter 10**.

"Sustainability depends on several interrelated systems. Each is essential for the survival of humans on Earth. This means that priorities cannot be argued over nor can there be speculation about which of these systems humankind can afford to lose first."
Walter R. Stahel, The Product Life Institute, Austria (Stahel, 1997a)

CHAPTER 9 SPSD CASE STUDY EVALUATION

9.1 INTRODUCTION

The best way to really understand whether the SPSD approach was effective in practice was to implement it in a representative case study group of companies, evaluate the results and review the SPSD approach on this basis. This case study evaluation is described in this chapter.

A Case Study Protocol to conduct the evaluation was designed and used. This defines the case study aims, questions, data collection, reporting and analysis and is outlined in section **9.2.** The analysis results are detailed in section **9.3.** The evaluation conclusions and the changes to be incorporated in a revised SPSD approach are summarised in **9.4**. Summaries of the individual case studies can be found in **Appendix 9.**

9.2 CASE STUDY OVERVIEW

In line with recommended case study research practice, a protocol to provide a rigorous and methodologically sound structure for conducting the case study evaluation was designed. This also provided a guide used by the researcher during the case study phase. As multiple case studies were proposed a strict protocol was important to ensure reliability of the case studies and the analysis conducted (Yin, 2002). The components incorporated in the Case Study Protocol included:-

- ❑ Case study aims and questions;

- ❑ Information sources, data collection and recording;
- ❑ Analysis method.

The protocol has already been described in **Chapter 2**. These components are summarised in **9.2.1 – 9.2.5**.

9.2.1 Case Study Aims and Questions

The aim of the case study was to evaluate the experiences of companies in real life SPSD implementation using the new approach in order to assess the effectiveness and practical use of the SPSD implementation approach as a support for industry and practitioners in the development of sustainable offerings. The feedback from the experiences was used to revise the SPSD approach. The evaluation was to determine the final two research questions, defined as the **case study questions:-**

9. *Does the implementation using the SPSD approach result in the development of offerings (products, services or PSS) with TBL sustainability benefits (environmental, social and economic)?*
   Note: offerings with TBL sustainability benefits were defined as preventing, where possible, or minimising adverse sustainability impacts.

10. *What are the experiences and views of implementing companies as to the effectiveness and practical use of the SPSD approach as a support for the development of sustainable products and/or services?*

9.2.2 Information Sources : Case Study Companies

The **unit of analysis** required for the case study evaluation was the implementation of SPSD in companies using the SPSD approach. Ten companies and their respective supply

chain companies participated as ten SPSD evaluation cases. This therefore involved 59 companies in total.

A full description of each case study is in **Appendix 9**. As an overview, the following characteristics of the evaluation cases are illustrated in **Table 9.1**:-

- sector;
- offering developed (product, service or PSS);
- size and role in supply chain of the companies involved per case.

This illustrates the diversity of sectors, offerings developed, organisation sizes and roles in the supply chain. The size of the companies varied including large companies and SMEs, playing different supply chain roles to include Original Equipment Manufacturers (OEM) as well as suppliers to different tiers (tier 1 supplying directly to the OEM, tier 2 supplying the tier 1 supplier and so on).

Table 9.1 General Characteristics of Case Study Evaluations (* RM = raw material)

	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9	CASE 10
Sector	**Electronics**	**Electronics**	**ICT**	**Furniture**	**Consumer Products**	**Plastics**	**Packaging**	**Timber**	**Healthcare**	**Furniture**
Case Description	SPSD on existing product	New offering	SPSD on existing product	SPSD on existing product	SPSD on existing product	SPSD on existing product	New offering	New offering	SPSD on existing product	New offering
Offering developed	Electronic automotive component	None - Analytic equipment proposed but not developed due to technical feasibility problems	PSS - upgradable PC & maintenance, repair, upgrade and end of life services	PSS - upgradable office chair & maintenance, repair, upgrade and end of life services	Reusable toner cartridges	Heated water tanks for industrial applications	Reusable micro electronics packaging	PSS - collection of wood waste and manufacture of ornamental wood chip mulch	Medical device packaging	Stackable commercial seating
Companies Involved (Sizes and Supply chain roles)	4 x RM* suppliers (SME & large); 1 x SME component assembler; Tier 2 component supplier; Tier 1 SME customer; end OEM customer	SME OEM; 3 x SME RM suppliers	SME, OEM; 7 x RM suppliers (SME & large); 3 x assemblers (SME); 2 x end of life recovery operators (SME)	SME, OEM; 4 x RM suppliers (SME & large)	SME, tier 1 supplier; 2 x RM suppliers (SME & large); end OEM customer	SME, OEM; 3 x RM suppliers (SME & large); 1 x SME component assembler	SME, OEM; 4 x RM suppliers (SME); 1 x mould tooling contractor	SME, OEM; 6 x RM suppliers (SME)	Large, OEM; 8 x RM suppliers (SME & large)	SME, OEM; 3 x RM suppliers (SME & large)

9.2.3 Case Study Evaluation Process

The case study evaluation involved ten case examples implementing SPSD using the new draft SPSD approach[1]. The duration of the SPSD implementation evaluation cases varied from eight to eighteen months with the ten evaluations mainly conducted concurrently over the 2001-2003 time period. With the exception of two companies, none of the companies involved had incorporated sustainability in product and/or service development before. As illustrated in **Table 9.1**, in six test cases the approach was applied to existing products in order to develop a more sustainable offering. In four cases there was no existing product and/or service and SPSD was applied in order to develop a new sustainable offering based on the participating company (ies) initial concept. For each evaluation, the stages of the draft SPSD were followed:-

- Planning
- Offering Development
  - ⇒ Concept Development
  - ⇒ Detailed Design
  - ⇒ Testing/Prototype
  - ⇒ Offering Launch and Marketing
  - ⇒ Offering Review.

The structure of the draft SPSD approach used for the evaluation cases incorporated documentation of the implementation process stages and a range of supporting materials to include training materials e.g. Powerpoint presentations and handouts, supporting tools, information supports e.g. databases and checklists. The following support materials were used as part of the process:-

- Introductory Information Module
- SPSD Sustainability Assessment Checklist

[1] For further detail on the draft SPSD approach see **Chapter 8.**

- Ongoing Information Supports
  - ⇒ Sustainable Products and/or Services Database of information resources
  - ⇒ Legal compliance obligations
  - ⇒ Industry schemes, voluntary standards and eco labeling specifications
  - ⇒ Information from supply chain companies e.g. data on raw materials, components and assemblies
  - ⇒ Data on alternatives (e.g. materials and energy sources) from existing data sources e.g. suppliers and databases
- Support tools e.g. abridged LCA. The support tools used are discussed in section **9.5.6.**

As part of the SPSD approach, expertise relevant to developing sustainable products and/or services is recommended to act as a mentor guiding and facilitating the implementation process from start to finish in line with the documented stages. This mentor for each case was the researcher. The cases typically involved a range of multidisciplinary stakeholders, to include personnel in the initiating company, suitable representatives from supply chain companies, B2B customers and external expertise (to include environmental consultants, industry consultants and the researcher as the SPSD mentor). The initiating company personnel involved came from a range of functions (e.g. the CEO, an overall project manager, Environment Manager, designers, engineers, R&D, financial, purchasing and marketing personnel). The project team for each case is outlined in **Appendix 9**.

The organisation and management of each case is described in section **9.5.1**. As part of the organisational arrangements regular project status meetings at each case company site were held at approximately two month intervals. At the end of the implementation, a case report developed by the project team (excluding the researcher) was provided. This report had a predefined format to include the following information:-

- Project description;
- Results obtained;
- Sustainability benefits;

- Commercial and other business benefits;
- Proposed future action;
- Costs incurred in conducting project.

A close out meeting was also conducted by the researcher at which final information was obtained and clarified.

9.2.4 Data Collection and Recording

The information to be obtained from the evaluation cases was to enable the case study questions to be answered. A *SPSD Evaluation Case Study Information Collection Template* was designed to facilitate obtaining the information to answer these questions. This template is provided in **Appendix 8.** The detailed information required by the Template includes the following categories of data:-

- SPSD Test Case Profile;
- SPSD Test Case Description;
- Description of each case outcome in terms of:-
    - Offering Developed
    - Sustainability impact (environmental, social and economic impact)
    - Other business impacts;
- Drivers for each case;
- Experiences and views of the participant company(ies) for each SPSD implementation stage;
- Ongoing supports provided, used and the role they played;
- Other influences/issues for the experiences identified;
- Data Sources used to complete the template.

The information was obtained throughout the duration of the evaluation cases through participant observation, direct observation, interviews, archival records, documentation and

physical artefacts (e.g. the offering developed) – the six sources of information recommended for case study research (Yin, 2002). In particular, empirical data was obtained through participant observation by the researcher. Information from the mainly multidisciplinary team participants in each case was obtained through the researcher's participant observation role at regular meetings. The benefits and drawbacks of participant observation as a data collection technique have already been discussed in **Chapter 2**. As the case study evaluations lasted over an extended period of time, there was much opportunity for accessing data throughout all stages of SPSD implementation and under different conditions. This provided additional opportunities for data validation as well as alternative/rival explanations for why aspects of the SPSD approach did, or did not work effectively, to be investigated. The participant observation data collection technique was backed up by:-

- semi structured interviews with the project manager for each case implementation;
- a report of each case developed by the implementation team (excluding the researcher);
- additional documents and information on the project;
- the final product and/or service resulting (some in prototype form and others completed and operational).

The semi structured interviews were typically conducted with the company personnel with overall responsibility for the SPSD implementation and the project manager of the initiating company. The template in **Appendix 8** was used to guide the interview sessions.

A case study database of the data collected for each case study was maintained and included:-

- Completed Case Study Information Collection Template from all data sources;
- Case report(s);
- Associated documentation relating to the companies involved, product (s) and/or service(s) and researchers notes from the ongoing case SPSD implementation process.

Based on the information collected, a description of each case is provided in **Appendix 9** including:-

- Sector;
- Case description;
- Offering developed;
- Initiating Company
  - ⇒ Size, Supply Chain Role & customer;
- Involved companies
  - ⇒ Size and Supply Chain Roles;
- Team
  - ⇒ Initiating Company
  - ⇒ External to Initiating Company;
- Existing sustainability related culture in initiating company;
- Existing product and/or service development systems;
- Drivers;
- Sustainability Impacts
  - ⇒ Environmental Impact
  - ⇒ Social Impact
  - ⇒ Economic Impact;
- Other impacts;
- SPSD Implementation stages;
- Supporting tools used;
- Supply chain organisation locations;
- Importance of sustainability benefits to marketing/brand;
- Third party validations obtained e.g. eco labels;
- Follow up application to other products and/or services;
- Data Source (for semi structured interviews).

9.2.5 Commercial Confidentiality

For the evaluation cases, information deemed as commercially sensitive was maintained as confidential. The commercial confidentiality requirements did not impact on the data required for the SPSD test case studies as this was largely generic information associated with the sustainability impacts of the offering and the effectiveness of using the SPSD implementation approach in practice. For confidentiality reasons, no case study information presented includes names of companies, specific personnel and other commercially sensitive details e.g. detailed data on resultant cost savings, detailed changes in offering specification etc. Each case is referred to as a number (Case 1-10) and the participants in terms of their functional roles. The semi-structured interviewees are identified by their function. This information is included in the case descriptions in **Appendix 9**.

9.2.6 Analysis Method

The unit of analysis and the criteria for interpreting the findings were developed as part of the Case Study Protocol. This was to ensure the data were treated fairly, alternative interpretations considered, and to produce valid analytic conclusions (Yin, 2002). The unit of analysis and criteria for interpreting the findings are summarised in **Box 9.1.**

Box 9.1 Case Evaluation Analysis

Unit of Analysis

The Unit of Analysis which defined what to analyse, was SPSD implementation using the draft SPSD approach in ten individual case study evaluations. The information obtained (as per the *SPSD Evaluation Case Study Information Collection Template*) from each case provided the data for analysis.

Criteria for interpreting the findings

Direct success or failure criteria for interpreting the findings only really applied to one part of the evaluation – whether an offering with TBL sustainability benefits was generated from SPSD implementation or not. The development of an offering with TBL sustainability

benefits using the SPSD approach can be defined as a successful outcome. However, there are limitations to using this criterion here. First, while a successful outcome in terms of an offering with sustainability benefits can result, there are many reasons why this may occur i.e. many reasons why the companies may achieve success and failure outside of the approach used. In these case studies, the approach is the focus of the evaluation. Second, success is an indication of whether the SPSD implementation process works regarding improved sustainable offerings and being effective and useful as a support. Third, sustainability benefits can be achieved to different extents. For these reasons, two main criteria for interpreting the findings were used as follows:-

- Sustainability Impact;
- Feedback.

Sustainability Impact

The sustainability impact of the offerings resulting per case were evaluated as having TBL sustainability benefits or not. The contribution of the SPSD process or not towards developing an offering with TBL sustainability benefits was determined. Other influencing factors identified were also highlighted.

TBL sustainability was assessed in terms of environment, social and economic issues. The actual criteria under each of these headings used were based on the criteria used to assess TBL sustainability in the *EU ECOLIFE II* programme (ECOLIFE II, 2003). Based on this, a TBL sustainability benefit is defined as meeting the following:-

Economic:

- Improvement of efficiency (i.e. a certain positive relation of costs and benefits in monetary terms)
- Improvement of productivity (i.e. a certain positive relation of output and input in quantitative terms)

Environmental

- Elimination/Reduction of material intensity
- Elimination/Reduction of energy intensity
- Elimination/Reduction of toxic/harmful material or materials of concern

Social:

- Improvement of health and safety for employees and consumer/society
- Improvement of workplace quality (modified from ECOLIFE II, 2003 p. 9)[2]

In addition to the *EU ECOLIFE* criteria defined under the economic heading, the commercial viability of the offering developed as determined by the participating companies in terms of bringing it into operation and making it commercially available, was observed as a measure of the economic impact.

[2] The modifications to the EU ECOLIFE II Criteria were to incorporate elimination as well as reduction in the environmental category.

The change in sustainability impact was in comparison to the existing offering previously produced by the case company, or in the cases where a new offering range was produced, the comparison was with the previous offering the company produced to meet the same functionality.

Feedback
The experiences of the test cases using the draft SPSD implementation approach were evaluated to determine its practical effectiveness and usefulness as a support in developing sustainable offerings, whether the criteria for effective SPSD implementation (as incorporated in the approach) worked in practice and any changes that would improve the approach. The experiences in terms of content of each SPSD stage as well as the overall structure of the SPSD approach were included. The results were evaluated to see whether and how the SPSD process contributed to the sustainability impact of the resulting offering or not. Whether the resulting offering had sustainability benefits or not, the feedback from all case experiences was evaluated.

As units of analysis, each case was analysed individually against the criteria for interpreting the findings. Individual case study reports were documented for each case. The individual case reports included the completed *SPSD Evaluation Case Study Information Collection Template* with the analysis results. Replication logic was used to show similar features or differences between cases and to be a basis for generalising from the results of all cases (Yin, 2002). Alternative explanations for the findings were investigated. Cross case conclusions were drawn and these are presented in section **9.3.**

The ability to use multiple sources of data in the cases enabled validation of the data. As recommended for case study research, a chain of evidence was maintained from the case study questions to the conclusions (Yin, 2002). This included the case study protocol itself, information collection template, case study database and case study reports (individual and cross case).

9.3 RESULTS FROM ANALYSIS OF CASE STUDY EVALUATION

Table 9.2 summarises the following case study results for each sector and case in terms of whether a TBL sustainability benefit (environment, social and economic) was achieved.

The commercial viability of the offering developed is also highlighted in the table. This table should be referred to during the discussion of results in this section. An offering was developed in cases 1, 3-10. Out of the nine offerings developed, three PSS and six products resulted. These are described per case in **Table 9.2.** Six offerings resulted from SPSD application to existing products (to include two of the PSS) and three were new. Case 2 failed to develop a product and/or service due to unresolvable technical feasibility issues associated with the new energy efficient technology proposed.

Based on a cross case analysis, replication logic revealed that an offering with TBL sustainability benefits resulted in nine cases to include case 1 and cases 3 -10. Of these nine cases, five (1,3-5,9-10) resulted in offerings with environmental, social and economic benefits. In cases 6-8, the offerings had environmental and economic benefits but social impacts were unchanged. In case 4 environmental and social benefits were identified, but economic impacts were unchanged. The results regarding sustainability impacts are provided in section **9.3.1.** The results on the feedback from the respective case study experiences using the SPSD approach are in section **9.3.2.**

Table 9.2 Case Characteristics & Sustainability Summary Results

	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9	CASE 10
Sector	**Electronics**	**Electronics**	**ICT**	**Furniture**	**Consumer Products**	**Plastics**	**Packaging**	**Timber**	**Healthcare**	**Furniture**
Case Description	SPSD on existing product	SPSD on new concept	SPSD on existing product	SPSD on existing product	SPSD on existing product	SPSD on existing product	SPSD on new concept	SPSD on new concept	SPSD on existing product	SPSD on new concept
Offering developed	Electronic automotive component	None Analytic equipment proposed but not developed due to technical feasibility problems	PSS - upgradeable PC & maintenance, repair, upgrade and end of life services	PSS - upgradeable office chair & maintenance, repair, upgrade and end of life services	Reusable toner cartridges	Heated water tanks for industrial applications	Reusable micro electronics packaging	PSS - collection of wood waste & production of soil improver	Medical device packaging	Stackable commercial seating
Sustainability Benefit	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Environmental	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Social	Yes	N/A	Yes	Yes	Yes	Unchanged	Unchanged	Unchanged	Yes	Yes
Economic	Yes	N/A	Yes	Unchanged	Yes	Yes	Yes	Yes	Yes	Yes
Commercially viable	Yes in operation	No	Yes In operation	Yes In operation	Yes in operation	Yes	Yes in operation	Yes In operation	Yes in operation	Yes in operation

9.3.1 Results for Sustainability

The TBL sustainability benefits observed for the offerings in case 1 and cases 3-10 included to varying extents:-

- Eliminated/Reduced adverse environmental impact;
- Reduced adverse social impact;
- Economic benefit.

These are summarised for all cases under the headings environment, social and economic below. Only the results are stated in this section. The contribution of the SPSD process or not towards developing an offering with TBL sustainability benefits based on the user experiences is discussed in sections **9.3.2.4** and **9.3.2.6.**

The individual environmental, social and economic impacts associated with each case are provided in **Appendix 9** and should be referred to throughout the discussion.

9.3.1.1 Environment

To determine environmental benefits in the offering developed, the following environmental criteria for TBL sustainability were used:-

- Elimination/Reduction of material intensity
- Elimination/Reduction of energy intensity
- Elimination/Reduction of toxic/harmful material or materials of concern (modified from ECOLIFE II, 2003 p. 9).

Based on the sustainability assessment conducted as part of the SPSD implementation, the adverse environmental impacts of the offerings developed in cases 1 and 3- 10 were reduced and incorporated these EU ECOLIFE criteria. In cases 1, 3 - 6 and 9 the offering developed had a reduced adverse environmental impact compared to the one previously produced by the company. In the cases where a new offering range was being developed,

the comparison was to their previous offering fulfilling the same functionality e.g. in case 7 the previous offering was non reusable cardboard packaging for micro electronics. The new offering was reusable returnable packaging for microelectronics.

The reduced environmental impacts and their extent varied per offering, but overall included the following:-

- Reduced material intensity
  ⇒ dematerialisation through a PSS approach (cases 3 and 4);
  ⇒ dematerialisation through eliminated and/or reduced raw material usage;
- Elimination and/or reduction in waste generation;
- Elimination and/or reduction in toxic/hazardous substances usage;
- Reduced energy intensity;
- Reduced emissions of pollutants to air.

9.3.1.2 Social

To determine whether the offerings had social benefits, the following social criteria for TBL sustainability were used:-

- Improvement of health and safety for employees and consumer/society
- Improvement of workplace quality (modified from ECOLIFE II, 2003 p. 9).

Based on the sustainability assessment conducted as part of the SPSD implementation, social benefits were achieved in six cases (1, 3-5, 9-10). The social impact reduction was limited in comparison to the environmental impact reductions achieved and mainly related to detoxification strategies providing health and safety benefits to employees and end users. In the main this was achieved through in plant social impact reduction and improvement in production related workplace quality for the participant companies. Cases 6-8 did not have social benefits and their social impact remained unchanged.

9.3.1.3 Economic

Economic improvement per case offering was determined in terms of the following economic criteria for TBL sustainability as well as commercial viability:-

- Improvement of efficiency (i.e. a certain positive relation of costs and benefits in monetary terms)
- Improvement of productivity (i.e. a certain positive relation of output and input in quantitative terms) (modified from ECOLIFE II, 2003 p. 9).

Based on the SPSD implementation sustainability assessment, a positive economic impact was observed in cases 1 and 3, 5 -10. In these cases, economic benefit was observed for the participating companies and for the end user. In case 2, no economic benefit was observed due to the implementation not being completed and no offering resulting. In case 4, economic benefits remained unchanged. The participant companies in all cases excluding case 2 deemed the offering developed commercially viable and put these into operation making them commercially available.

In terms of improvement of efficiency, cases 1, 3, 5, 6 and 9 where SPSD was applied to an existing product observed overall economic benefits in terms of cost savings from eco-efficiency improvements for the offering post SPSD (e.g. reduced material intensity, reduced raw materials costs, especially regarding hazardous materials) were observed. In these cases, reduced environmental impact was associated with cost benefit. The cost benefit is highlighted as a rival explanation for the changes resulting in these environmental impacts being implemented. While an overall cost benefit was observed for these cases, specific costs increased as well as decreased and this varied per case. For example, in cases 1 and 3 cost increases for some environmentally preferable raw materials were observed, but overall were balanced out by cost reductions associated with other eco-efficiencies e.g. reduced raw material usage. In cases 1, 3, 5, 6 and 9, competitive advantage was gained as a result of the cost savings which the companies were able to pass onto their customers. In particular, for cases 1 and 5, the cost reductions obtained have substantially increased the company's profitability, competitive advantage and markets.

Cases 7, 8 and 10 developed new offering ranges and an improvement in efficiency associated with the previous offering developed to meet the same functionality was measured. Based on this, cases 7, 8 and 10 showed a cost benefit for the company activities post development of the new offering.

Economic impact in terms of increased productivity was also assessed per case. This was an important factor to assess not only to determine the economic impact but also because an increase in productivity could have a negative rebound environmental impact through generating more units of production with associated increased resource usage, waste generation etc.[3] While environmental benefits could be achieved in their own right, an increase in productivity could negate this. By using the SPSD sustainability assessment which incorporated environmental, social and economic issues together, the environmental impact of an increase in production and visa versa was determined. Increased production in terms of increased number of units produced was realised in only one case. In case 7, the success of the offering developed was such that their customer increased their supply contract to be the global supplier of the offering whereas they had been the European supplier previously. This increased supply contract was replacing a competitor supplier unable to compete with the new offering. In terms of overall units produced for the customer, these were reduced as the new offering was reusable, but for the supplier the units to be produced were significantly increased as they were now the global supplier. Overall, the environmental impact in the global context was reduced with a reduction in the units being required with a reduced environmental impact per unit.

[3] An increase in production could also have a social benefit in terms of increased employment, but this was not included in the social EU ECOLIFE TBL sustainability criteria and hence was not assessed.

9.3.2 Experiences Relating to the Draft SPSD Approach

The experiences of the case studies identified by the participants implementing the SPSD approach in terms of its effectiveness and usefulness as a support for developing sustainable offerings are described in this section. These are categorised under the following headings:-

- SPSD Process
  - ⇒ Planning: Organisation, Management and Communication
  - ⇒ Planning: Provision of Information (Introductory and Ongoing)
  - ⇒ Planning: Strategy level commitment and integration into existing business systems
  - ⇒ Offering Development : Concept Development - Functionality, Systems, Lifecycle stages and the initial sustainability assessment
  - ⇒ Offering Development : Concept Development - Determine Supply Chain Dynamics and Engage Supply Chain Management
  - ⇒ Offering Development: Concept Development – Full Sustainability Assessment
  - ⇒ Detailed Design and Testing/Prototype
  - ⇒ Production
  - ⇒ Offering Launch and Marketing
  - ⇒ Offering Review
- Overall structure of SPSD approach.

These categories were chosen as they incorporate the experiences relating to the overall structure of the SPSD approach, the main stages of the SPSD implementation process and the criteria identified for effective SPSD implementation[4]. For each category the experiences are summarised followed by the specific feedback[5]. **Table 9.3** summarises case characteristics identified in the evaluation which are referred to during the description of the experiences.

[4] For further information on these criteria see **Chapter 6.**

[5] The details of each case example are summarised in **Appendix 9.**

Table 9.3 Case Characteristics relevant to Experiences of Users

	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9	CASE 10
Sector	**Electronics**	**Electronics**	**ICT**	**Furniture**	**Consumer Products**	**Plastics**	**Packaging**	**Timber**	**Healthcare**	**Furniture**
Offering developed	Electronic automotive component	None	PSS - upgradeable PC & maintenance, repair, upgrade and end of life services	PSS - upgradeable office chair & maintenance, repair, upgrade and end of life services	Reusable toner cartridges	Heated water tanks for industrial applications	Reusable micro electronics packaging	PSS - collection of wood waste & production of soil improver	Medical device packaging	Stackable commercial seating
Existing sustainability related culture in initiating Co.	Yes ISO14001	No	Yes	No	Yes ISO14001	No	No	Yes	Yes ISO14001	No
Management Systems e.g. Quality, Environment	ISO14001 ISO9001 QS 9000 Health & Safety	ISO9001 Health & Safety	ISO14001 in development Health & Safety	Health & Safety	ISO14001 ISO EN 9002 Health & Safety	ISO 9002 Health & Safety	Health & Safety	Health & Safety	ISO14001 ISO9001	Health & Safety
Existing Product Development System	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Importance of sustainability benefits to marketing/brand	No	No	Yes	Yes - specific markets	No	Yes - specific markets	Yes	Yes	Yes	Yes
Environmental Product Declarations obtained	None	None	Energy Star EU Eco label (PCs) under consideration	None	None	None	None	EU Eco label (soil improvers) consideration	None	None

9.3.2.1 Planning: Organisation, Management and Communication

Initial scoping meetings were conducted with the initiating companies to discuss the proposed case. This involved provision of information, developing objectives, a plan, estimating costs and identifying the likely team members. Details of the team, initiating and involved companies are provided in **Appendix 9**.

The company with control of the design of the proposed offering took overall responsibility for the SPSD implementation. In eight cases (Cases 2-4 and 6-10) this was the Original Equipment Manufacturer (OEM). In cases 1 and 5, both focusing on specific components of a larger product, it was the tier 2 and tier 1 suppliers respectively (who manufactured these components) that took overall responsibility with key involvement and final approval from their OEM customers.

The project team typically involved a range of stakeholders to include:-

- representatives from each key business function (to include product design and development, environment, quality, health and safety, operations, purchasing, finance, marketing) in the company taking overall responsibility for the SPSD implementation;
- suitable representatives from supply/value chain companies upstream and downstream (e.g. raw material suppliers, assemblers, component manufacturers, end of life recovery, recycling, treatment/disposal companies);
- Business to Business (B2B) customers (in cases 1,5 and 10 only);
- external expertise (to include environmental consultants, various industry consultants and the researcher as the SPSD mentor).

In the company taking overall responsibility, a project manager took individual responsibility for the project. The existing role of the project manager in the company varied to include Product Development (2 cases), R&D (2 cases), General Manager (4 cases of small SMEs) and Environment (2 cases). The project manager was answerable to

the company CEO for final completion as part of the initial strategy commitment[6]. In all cases, the project manager in the company taking overall responsibility for the SPSD implementation reporting directly to the CEO was identified by the interviewees as an important driver to the project team to ensure ongoing commitment and progress in the cases. Interviewees from nine cases (1, 3 and 4-10) noted the co-ordinating role of the external mentor as important to ensuring the offering development went to completion. The case 2 interviewee commented that their offering did not go to completion due to technical feasibility issues irrespective of the roles of the project manager or mentor.

Interviewees from nine cases (1, 3 and 4-10) noted that the SPSD implementation was facilitated by the provision of SPSD expertise in the form of an environmental consultant and the SPSD mentor in all cases. Of these, interviewees in six cases (1,3, 5 and 8-10) noted that having this expertise facilitated the knowledge transfer and learning curve for the companies as well as the overall implementation process. Interviewees in all cases noted that because a number of the implementation stages and concepts were new to participants[7], SPSD related expertise was required as part of the process to ensure successful implementation. A resultant amendment to the draft SPSD approach was to include an explicit recommendation to incorporate SPSD related expertise in order to facilitate the process.

The project team members were not always obvious at the outset of the test, especially in the cases where a new offering was being developed. Therefore, the identification of the full project team did not always happen at this early stage. Project team members were added on after the Concept Development phase in some of the projects, as after this stage it was clear what offering (product, service or PSS) was to be developed, what the lifecycle stages entailed and hence all the stakeholders. This involved revisiting some elements of the SPSD implementation (e.g. provision of information, initial sustainability assessment) with new project team members.

[6] See **9. 3.2.3** for further information on the strategy commitment.
[7] See **9.3.2.2** for further information on this.

The management arrangements started with the initial scoping meetings with the initiating company. Once the company taking overall responsibility was agreed, a meeting with the CEO and senior management took place to provide suitable introductory information and agree the strategy level commitment. In most cases this entailed several meetings rather than one to facilitate personnel who were unavailable, clarify information, discuss the strategy commitment etc. Once the key project team members were identified, an initial meeting was held to communicate the aims, deliverables, team members and their roles. The introductory information provision session was also included in this session. Supply chain representatives were involved in person as well as by phone and email especially for those located in other countries. The meeting(s) were organised by the project manager with the information provision session conducted by the SPSD mentor with support from the consultants, as relevant. The subsequent meetings involving the full project team were at the concept development stages. For the remaining stages (detailed design and onwards), project team members were involved on an as needs be basis. In all cases except case 2, at the completion of the Offering Review stage of the implementation, final meetings were held with the CEO, senior management and the full team to communicate the final results of the implementation. As case 2 did not finish the implementation, only a closing meeting to identify feedback from the steps completed took place.

While it was not always possible to get all team members to attend all meetings, in the main the attendance was sufficient to achieve the aims. As required and at a minimum two monthly basis, status meetings were conducted involving the SPSD mentor and project manager to assess progress to date, changes required to the implementation structure, process, team etc. Interviewees from cases 1-3, 5-7 and 9 stated that the frequency of the meetings was suitable and useful for driving progress. Cases 4, 8 and 10 noted that the number of meetings could be reduced. It was observed that these cases were less complex than the other cases and did not need to meet as often. As a revision to the SPSD process, flexibility with respect to full project team meetings based on the nature of the offering development is to be incorporated.

9.3.2.1.1 Resources

In cases 1-8 and 10, the number of participants involved were noted by interviewees as larger and more multidisciplinary, in comparison to the existing product development processes already used by the companies. Case 9 was the only case where the interviewee stated that the number and multidisciplinary nature of the team was similar with the exception of the external environmental consultant and SPSD mentor. The interviewees in cases 1-8 and 10 noted that the number of personnel involved in the SPSD implementation was increased for the following reasons:-

⇒ because the CEO and senior management were involved at the initial stages in terms of information provision and securing strategic commitment;
⇒ a multidisciplinary team representing all business functions in the company taking overall responsibility for SPSD and representatives from the key supply chain companies were involved in the offerings development.

This increased personnel involvement reduced after the introductory information provision, concept and initial design stages, as the input required from the multidisciplinary representatives had been achieved at that stage. However, the personnel resource used in the remaining detailed design and development stages was still reported by all interviewees except case 9 as higher than the number involved in previous product development implementations, as greater interaction with internal business systems (in particular quality, purchasing, operations and environment) and with supply chain partners took place.

Interviewees from all cases commented that the multidisciplinary nature and structure of bringing the project team together to conduct key stages of SPSD was effective in facilitating management and communication throughout the project. However, cases 1-8 and 10 (with the larger number of team participants), noted on the negative side that increased personnel involved increased time and associated cost. Increased cost associated with the increased time commitment of personnel could be seen as a negative feature of SPSD, or that it would be poorly implemented.

In two cases (2 and 3), where the company taking responsibility for SPSD implementation was an SME with < 50 employees, the multidisciplinary functions represented by these SMEs did not always equate to the same number of individual people participating. This is because one person was responsible for two or even three roles within the company, e.g. quality, environmental and health and safety (QEHS) manager.

In the eight cases (1,3 and 5-10) where cost benefit was associated with the offering developed, these interviewees stated that the benefits achieved to the end offering due to the increased involvement of the multidisciplinary personnel (especially from key supply chain companies) outweighed the increased time cost. This would require future testing.

It was also observed that the personnel and cost allocation would be reduced for subsequent SPSD implementation in the same company (ies) as certain stages would not be required – most notably such a comprehensive introductory information provision session and final closing sessions. This was to be highlighted in the planning stages of the revised SPSD approach to inform participant companies that an upfront increased time commitment was likely, but this could be reduced in subsequent implementations.

In terms of the time required for the implementation, interviewees in three cases (2, 4 and 8) noted that the time from concept to market was greater than their normal product development and was seen as a negative feature to gaining competitive advantage. Interviewees in cases 1-3, 5-7 and 9-10 identified that while there were increased stages in the offering development process, the time from concept to market was the same because the communication and participation from supply chain participants early in the process was more effective.

9.3.2.1.2 Language

In each case the business language of the companies and industry sector involved was used as much as possible. New SPSD related terms were introduced in all cases, but the aim was to explicitly minimise these and where possible "translate" these into the relevant business language (where this existed). As a result, the words used varied on a case by case basis. In the provision of introductory information stage of SPSD, new terms were introduced e.g. Sustainability, SPSD and PSS. As illustrated in **Table 9.3**, in five of the cases (Case 1,3,5 and 9) where the initiating companies had an existing environmental culture, they recognised some of these terms with initiating companies in Cases 1,5 and 9 already familiar with ecodesign concepts. In these cases, where terms were already recognised, they were used. The concepts represented by terms such as sustainability, PSS and SPSD were stated by interviewees from all cases as new and difficulty with understanding the terms was initially observed during the Initial Information Provision stage[8]. Overall the terms sustainability, SPSD and PSS were not used after the introductory provision step in any of the cases as they did not exist in the existing culture of the majority of the companies involved with the exception of the two multinational OEM end customers in case 1 and 5 (note SPSD and PSS were not in the existing language of any of the companies involved). Terms used included:-

- "products and/or services" instead of PSS (in cases 3, 4 and 8) as the companies believed this incorporated the combination of a product service system;
- developing "superior","innovative" or "quality" products and/or services.

It was observed that the companies were comfortable and able to achieve similar aims using less specific language in comparison to the external practitioners who were more

[8] See **9.3.2.2** for further information on the difficulties experienced .

comfortable using the specific terminology relevant to SPSD and had to make a greater effort to use the business language. This highlights an important message for sustainability practitioners and the communication of sustainability concepts in business. This was important feedback for the SPSD process to explicitly highlight the communications benefits of customising language use into the process.

In all cases, interviewees highlighted the use of recognised business language and minimisation of new jargon as key to effective communication and as a result were seen as a factor in achieving a successful implementation. Interviewees from cases 1, 5, 6 and 9 highlighted this as especially important as the SPSD approach used required the integration of multidisciplinary business functions and supply chain organisations, hence a recognised common language and effective communication were essential.

9.3.2.2 Planning: Provision of Information (Introductory and Ongoing)

Introductory supporting information, as well as ongoing information, was provided in each case. The information requirements varied per case in light of the existing knowledge of the companies, sector, product and/or service, culture etc. In each case the information provision was customised to suit the situation. The introductory supporting information included the following:-

- The business case for developing sustainable products and/or services;
  - ⇒ Why develop sustainable products and/or services?
  - ⇒ Legal and market drivers relevant to each case
    - compliance requirements
    - standards, Environmental Product Declarations (e.g. labelling)
    - industry initiatives;
  - ⇒ Expected outcome and business benefits.
- A description of the SPSD process;

- How does SPSD fit within my existing sustainability, environmental, product and/or service development and other business systems?
- Potential pitfalls;
- Case examples relevant to the sector and offering likely to result;
- Information resources;
- Introduction to the *Sustainable Products and/or Services Database* of information resources[9].

The introductory supporting information was provided by the SPSD mentor and the environmental consultant(s) relevant to the case. An introductory information session(s) was given to disseminate this information to the full multidisciplinary case study team plus the CEO and senior management of the company taking overall responsibility for SPSD implementation.

The ongoing supporting information varied in each case depending on the requirements. Some examples of the information provided included specific information resources mainly relating to technical feasibility issues (e.g. providing lead free solder data for the electronics sector cases), databases of alternative raw material options, the *Sustainable Products and/or Services Database*. Supply chain companies were key to provision of information on raw materials, components, assembly, disassembly etc. The ongoing information was provided by the SPSD mentor, environmental consultant(s), industry specific consultant(s), supply chain companies and other third parties, as relevant to each case.

Interviewees in all cases commented that the provision of introductory supporting information as the first stage in each case and ongoing provision of information, was useful and necessary for the implementation, in particular in light of the new concepts it incorporated. Difficulties and cynicism with the new concepts introduced were observed at the introductory information provision stage in seven of the cases (1,4-10.). In particular,

[9] This database was developed as an information resource for the SPSD approach . A copy is in Part IV of the SPSD Guide on the CD ROM attached to **Chapter 10**.

the focus on functionality and considering alternative options for its provision via not just products but also services and PSS and consideration of the wider systems the likely offering would operate in were noted as new and challenging concepts in all cases. Interviewees in cases 1-3 and 6-10 identified these supports as facilitating commitment and understanding early on within the multidisciplinary group. Interviewees in all cases reported capacity building benefits in terms of knowledge and expertise associated with the SPSD implementation process.

The ongoing information supports especially from supply chain companies and external specialists were noted by interviewees from cases 1-3, 6 and 9 as key to identifying realistic product and/or service options particularly with respect to technical feasibility and manufacturability. Cases 1, 2 (electronics sector) and case 3 (ICT) stated that this was mainly due to the following:-

- their complex supply chains, in different locations with a number of suppliers performing different roles;
- lack of internal expertise on new technical options e.g. RoHS[10] compliance.

Cases 6 (plastics sector) and 9 (healthcare) stated ongoing information was key to ensuring they had the necessary information to ensure the offering met its functional, quality and technical specification. In eight of the ten cases (cases 1 -6, 9 and 10), difficulty in gaining accurate information on alternative raw materials, components and assemblies from supply chain companies and other sources were noted by interviewees as limiting factors in identifying potentially more sustainable options. Significant time resources were required to obtain the information required and in some cases this information proved not available. In particular, the electronics (cases 1-2) and ICT sector (case 3) examples, with their complex supply chains found difficulty accessing all the information required. Roadmaps and Bills of Materials were used within these supply chains to obtain information on materials. However, complete and accurate information was not easy to obtain. In these cases it was observed that, raw material and component suppliers, in particular, were not

[10] Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive (EC, 2003b)

used to being asked for the data required and had to invest resources in sourcing and documenting it, where it was available. Without complete information, companies in cases 1 and 3 were not able to fully assess the technical feasibility of all the options identified for providing their sustainable offering, hence a potentially more sustainable option could not always be assessed fully as the technical feasibility was uncertain. Case 2 was a good example of a more sustainable offering being developed which was based on a new technology which resulted in significantly improved energy efficiency but, was not technically feasible to bring to operation. Interviewees in case 7 (packaging) and 8 (timber) stated ongoing supporting information was adequate to fully assess impacts during their implementation. In comparison to the others it was observed that the information requirements of these cases were less complex and readily available.

9.3.2.3 Planning: Strategic commitment and integration into existing business systems

The case companies responsible for SPSD implementation made a commitment to conducting their overall activities in a sustainable manner and, as part of this, to develop sustainable offerings. In all cases the commitment was to conduct their activities and provide offerings that met customer requirements, were economically viable, met other relevant offering criteria and were environmentally sound and socially responsible. Overall, this meant a commitment to the existing business goals, with the recognition that the offering could be products, services or PSS, and with environmental and social criteria incorporated with existing offering criteria.

In all cases the commitment was made by the companies taking responsibility for the SPSD implementation. In eight out of the ten cases (2-4 and 6-10), this was the OEM. In the remaining two cases (1 and 5), these were suppliers (Case 5 was a tier 1 supplier to an OEM and Case 1 was a tier 2 supplier to a tier 1 supplier to an OEM). Both OEMs have well publicised sustainability programmes incorporating their products and services. In case 5, the tier 1 supplier made the strategic level commitment as well as the OEM who saw this commitment as already in place in their strategy. In case 1, the tier 1, tier 2 suppliers and

the OEM made the commitment who also saw this as part of their corporate strategy. Both the OEMs in these cases, while not initiators of the SPSD implementation for the existing products in question, were positive about the initiatives and part of the SPSD implementation team.

The process of making the strategy level commitment involved the CEO (of the company taking overall responsibility for the SPSD implementation) and their senior management (representing each business function) agreeing to the commitment. Typically this was incorporated into the company's existing strategy statement (e.g. company mission statement where this existed). In cases 4 and 10 involving SME companies, they did not have a documented strategy and did not chose to change this, instead using an agreed commitment among the senior management team. For companies with ISO14001 (three cases - 1, 5 and 9) and ISO9000 (five cases – 1,2,5,6 and 9), the commitment was seen as consistent to their existing environmental and quality policy statements respectively. In two of the three ISO14001 accredited companies (cases 5 and 9) the environmental performance of their respective products and/or services was not considered in their EMS. In these two cases, the Environmental Policy Statement was revised to incorporate the commitment to sustainable products and/or services.

Supply chain company project team members also agreed to this commitment as part of their involvement in the case, but did not incorporate this into their respective company's corporate strategy statement or Environmental Policy Statement, where these existed, as this was not a requirement of the process[11].

From the strategy level, the commitment was integrated into all business functions (in the company taking overall responsibility for the SPSD implementation) to include product and/service development, finance, operations, purchasing, marketing, quality, environment and health and safety (as relevant to each company). Where an existing product development system was in operation (in nine out of the ten cases (1-3 and 5-10)), the

[11] This excludes the tier 1 supplier in Case 5 and tier 1 and 2 suppliers in case 1 who were initiators and formally incorporated the commitment into their strategies.

SPSD concepts and approach were incorporated within this. Where environmental (cases 1, 5 and 9 had ISO14001 certified EMS with case 3 developing an ISO14001 EMS), health and safety (all cases had health and safety systems) and/or quality management systems (cases 1,2,5,6 and 9 had ISO9001/2 certification) existed, the SPSD approach was integrated as relevant with these systems. For the other business units (operations, finance, marketing and purchasing), SPSD was integrated as relevant. This integration was noted by interviewees in cases 1 and 5-10, to build an operational framework for the SPSD implementation to build on the existing strategic level commitment hence facilitating the implementation. Incorporation of environmental and social criteria with existing business systems was noted as making the commitment pragmatic and part of the existing business mission. Interviewees in cases 4 and 10 stated formalised integration was unnecessary within their small companies as the number of case team members was small with a number of individuals playing multifunctional roles.

Of the three cases (1, 5 and 9) with an ISO14001 certified EMS, only case 5 already incorporated environmental performance improvement targets for their products. In cases 1 and 9, the development of sustainable products and/or services was added to their Environmental Objectives/Targets and Environmental Management Programme as part of the integration of SPSD with the existing EMS.

The interviewees in 8 cases (1 and 4-10) stated that the participants in non environment related business functions found the integration of environment and social criteria in the overall business mission difficult to relate to at the beginning. Interviewees from cases 2 and 3 stated that while integration of environmental and social criteria across all business activities was difficult, the fact that in these small company cases, the same people were fulfilling a number of roles helped the integration, as fewer people had to be incorporated. All cases noted that team members from non environment related business units did not see environment and social criteria as being part of their roles at the commencement of the implementation. All cases noted that the introductory information provision, in particular the business case rationale, was helpful for these personnel to understand why and how the environmental and social criteria were being incorporated. However, cases 1, 5 and 9 noted

that their preference was that environmental and social criteria be driven from the environment and health and safety functions with input on an as needs be basis from the other business functions to include offering development. The difficulties non environment related personnel experienced in all cases was observed as an important barrier to SPSD implementation which needed to be overcome as early as possible in the implementation to ensure the required input from these personnel. Based on this feedback the information on the business case for SPSD provided in the introductory information provision was to be amended to better engage personnel from different functions.

Interviewees in cases 1-3 and 5-10 noted that the strategic commitment from the top downwards facilitated the buy in and co-operation of the non environment and social related business functions in the initiating company. Of these cases 1 and 5-10 stated that company commitment at the most senior level and in the business strategy facilitated integrating SPSD throughout the company's activities and hence the SPSD implementation. However, these cases noted that translating the commitment further into the formal objectives of business units was missing. The case 4 interviewee stated that formalising the strategic commitment was not necessary for gaining commitment in their company. In eight of the cases (2-4, 6-10) where the OEM was the company driving the SPSD implementation, the interviewee stated that meeting customer expectations and retaining or gaining new business was the likely expected key driver for supply chain companies. In cases 1 and 5 where the supplier was the company driving the SPSD implementation for their offering, co-operation from their suppliers was noted as due to maintaining business in what they expected would be a revised offering specification. In cases 1 and 5, co-operation and buy in from the OEM was noted as being due to the fact that the suppliers had demonstrated to the OEM that a value added offering was likely to result from what they perceived as a low risk project.

Other reasons why companies may have made the strategic and operational commitments were that they were willingly proactive about making their products more sustainable and

already had an initial engagement and commitment to this overall concept[12] through their interest in participating in the SPSD case evaluation. It is proposed this made gaining commitment in the case examples more likely than in companies without this initial engagement and commitment. The drivers for the engagement of these case companies were investigated as part of the evaluation and are included in each of the case descriptions in **Appendix 9**. The drivers identified included legal, market and financial factors. Four cases (electronics (cases 1 and 2), ICT (3) and packaging (7)) were driven by existing or impending legal compliance drivers. The two cases initiated by suppliers (1 and 5), stated that this was driven by a market demand through the supply chain from their OEM customers who were responding to a legal driver. All companies noted that they were driven by increasing financial costs associated with their environmental impacts, in particular increasing waste related environmental costs (e.g. increased cost of disposal to landfill and end of life recovery costs). Only case 3 noted being driven by an explicit company commitment to environmental protection. Cases 4 and 6 noted the potential business opportunities that an offering with improved sustainability performance might bring as drivers. No cases stated explicit drivers to improve social performance. At the completion of the implementation, the nine cases which developed an offering (excluding case 2) noted the social benefits associated with the offering developed as unexpected and very welcome.

A revision to the draft SPSD approach identified from the case evaluations under this category would be advising the issuing of a formal strategy statement incorporating the strategic commitment, as distinct from a less formal agreement. In the two cases (4 and 10) where a verbal commitment alone was made, this was observed by the researcher as less effective later on in the implementation when commitment and co-operation reduced over time. Also, to be included is the suggestion from cases 1,5 and 10 to translate the strategic commitment formally into performance related business unit goals as a useful way to maintain commitment at an operational and multifunctional level.

[12] albeit not necessary using this language.

9.3.2.4 Offering Development: Concept Development - Functionality, Systems, Life Cycle Stages and the Initial Sustainability Assessment

Under the SPSD approach, an extra step, Concept Development, was added to the beginning of the existing product development processes already used by the companies in cases 1-3 and 5-10. Case 4 had no formal development approach. In Concept Development, the functional need to be met by the end user was assessed to determine the most sustainable (environmental, social and economic) way of providing that function. That incorporated the following elements:-

- Considering all options for providing the required functionality, to include whether it can be provided by a service, product or some combination of a PSS;
- Consideration of the wider systems in which the product and/or service currently/will operate in throughout its entire lifecycle;
- Identification of all potential product and/or service lifecycle stages;
- Initial sustainability assessment of the functionality, environmental and social issues likely to be associated with all lifecycle stages for the proposed options.

Brainstorming and concept development sessions with the multidisciplinary project teams were used and an open minded approach as to how the function could be provided. The lifecycle stages associated with the offerings proposed were identified and sustainability impacts assessed. The SPSD Sustainability Assessment checklist was used as a guide for the initial assessment. The aim was to limit this assessment to provision of the functionality while maximising environmental and social performance. Other traditional criteria were excluded in this initial assessment, so as not to limit creativity and identification of all options which maximised environmental and social benefit. Once these were identified, the traditional criteria were added to the assessment.

Based on feedback from interviewees and participant observation, it was noted that all case studies experienced difficulty with the following which was seen as new territory in terms of the product and/service development process:-

- shifting the mindset from providing products to providing functions to meet human needs and consideration of alternative ways to provide the function(s) such as services or PSS;
- identifying the potential alternatives to provide the functionality and the associated lifecycle stages;
- identifying the systems in which the proposed offering would be likely to operate in;
- not incorporating traditional criteria e.g. cost in the initial assessment.

These difficulties were not unexpected. The provision of the introductory information which incorporated an introduction to functional based offering development and some existing industry examples customised per case (as available) were noted by interviewees in all ten cases as important for facilitating the Concept Development stage. However, interviewees from eight cases (2-4 and 6-10) noted that even with the introductory information, ongoing practice would be necessary to become comfortable with the concepts and approach.

The companies with an existing environmental culture (five cases - 1,3,5,8 and 9) found the adjustment to the concept development thinking quicker than those that did not. Of these five cases, the three with ISO14001 certified EMS (cases 1,5 and 9) did not seem to have a significant advantage, largely because these ISO14001 systems did not incorporate these concepts. Interviewees from cases 1, 5, 6 and 9 highlighted that non environmental and non product development related personnel in the project team found these Concept Development stage issues the most difficult. In conducting the initial Sustainability Assessment, these cases noted the participants were more comfortable incorporating the traditional product and/or service criteria on the checklist than incorporating the new criteria relating to functionality, systems, environment and social impacts.

In order to give additional guidance to facilitate participants regarding what should be considered during Concept Development, further information is to be included in the SPSD Sustainability Assessment Checklist on the following:-

- potential issues to be considered when determining how to meet a functionality
- potential issues to be considered when determining the wider systems interaction the offering could have during its lifecycle.

Also, the importance of keeping an open mind and not focusing exclusively on one mode of delivering the functionality (e.g. a service, product or a PSS) is to be made more explicit in the approach. It was observed in the initial assessment sessions, that companies can easily fall into the trap of focusing on an offering type that they may perceive as more sustainable (e.g. a PSS) and develop a more complex (and potentially less sustainable) offering to meet this structure. The importance of considering and assessing each potential option for meeting the functionality (product, service, PSS or other) in its own right is to be made more explicit.

Interviewees in eight cases (2-4 and 6-10) stated that by incorporating the Concept Development phase, the opportunity to identify options for the provision of a more sustainable way to provide a required functionality was provided. The contribution from assessing the functionality, considering alternative ways to provide it, incorporating all lifecycle stages, using a closed loop approach and including the impacts associated with the offerings wider systems interaction towards developing a more sustainable offering varied across these cases and contributed mainly to improving environmental performance. In all cases, consideration of what the offerings functionality was to meet a human need, did not result in a revolutionary way to provide the functionality. It was observed that in all cases, the functions were not providing essential human needs e.g. food or shelter. Functions included providing seating in the furniture cases, protection and branding of goods in the packaging case and data processing/communication in the computer case. The participants aimed to provide the functionality to meet an end users (their customers) needs. This was observed as a different type of need.

By considering the functionality required by their end users, Cases 3 (computer PSS) and 4 (office chair PSS) determined that an offering which provided the required functionality over an extended operating life met the functionality with reduced environmental impact. The associated repair, maintenance and upgrade services were designed to ensure the ongoing functionality in terms of technology and continued operation was provided. Interviewees from cases 3 and 4 noted that without considering the functionality in this way, neither would have considered providing these services. By considering the wider systems both offerings would interact in over all their lifecycle stages and focusing on achieving a closed loop cradle to cradle lifecycle, the chair and computer respectively were designed to maximise the opportunities for reuse at eventual end of life with recycling as a secondary option. Without considering the systems interaction and all lifecycle stages, the interviewees stated that they would not have considered choosing the raw materials and designing the components to maximise recovery for reuse. In case 9, by assessing the functional requirement and the wider systems interaction of the medical device and its packaging a more sustainable offering resulted. One aspect of this was that the assessment of the functional requirement to disseminate instruction information to their healthcare end user and how this could be met in the most sustainable way resulted in the original paper instruction leaflets being eliminated and replaced by a pictorial diagram on the packaging itself. This dematerialisation resulted in the elimination of significant paper usage. It was observed in case 10 that by considering all lifecycle stages, the use of waste wood from the production process as a raw material in comparison to the original choice (virgin) contributed to reducing the environmental impact of the offering. By considering the wider systems interactions, all life cycles stages and a closed loop approach, case 7 identified that the provision of a reusable, returnable packaging met the required functionality required and significant waste reduction was achieved compared to the previous one trip, disposal packaging. The sustainability improvements identified for case 2 and achieved for the case 6 offering were due to assessing the sustainability impacts across all lifecycle stages.

Interviewees from cases 1 and 5 stated that their scope in considering alternative ways to provide the functionality was limited as they were applying SPSD to a component part of a

larger product over which they did not have design control[13]. Because they were designing a component to a specification from their OEM customers respectively, they were limited in the sustainability improvements which could be considered both in terms of alternative ways to provide the functionality required as well as the wider systems the offering would operate in. They noted that their ability to change this specification was limited due to their lack of control over the specification and this limited their opportunities for developing a more sustainable offering. In these cases the OEM end customers were part of the team, but not the initiating companies and SPSD was being applied to components of the overall OEM's offering. In particular, it was observed that in these cases, if SPSD had been applied to the OEM's end offering, more significant sustainability improvements were more likely to have been achieved as the scope of options in terms of alternatives for providing the functionality and assessing the impacts associated with the systems in which the end offering interacts would have been increased. These two cases highlight that in order to maximise the opportunities for a more sustainable result the following should be considered:-

- focusing on one component of an overall offering can limit the sustainability improvements possible,
- the end and wider systems level offering to meet a human need should be the focus of SPSD to maximise the sustainability improvements associated with consideration of alternatives for providing the functionality.
- The importance of those companies with design control of the end offering being the most effective target for SPSD implementation[13].

These case experiences reinforce the SPSD approach as it incorporates this thinking in terms of SPSD being implemented in the company with overall design control and including the functional and systems aspects. However, it does not explicitly state that SPSD should be applied to the end offering only and that is likely to give a more sustainable result. This is to be incorporated in the revision of the approach.

[13] See section **9.3.2.5**.

Interviewees in all cases except case 1 and 5 noted that assessing the sustainability impacts associated with the wider systems in which the proposed offering would be likely to operate was seen as a difficult concept to implement in practice by participants. It was observed that this was mainly associated with identifying fully the wider systems the offerings were likely to operate in and the associated increased scope of impacts to assess. As Cases 1 and 5 were developing a component of a larger product, the wider system was limited to impacts associated with the component operation in terms of the end products wider system operation. Hence the scope was limited and more defined compared to the other case offerings. Based on this feedback, guidance in terms of examples of potential issues to consider in identifying and assessing the impacts associated with the wider systems interaction is to be incorporated into the SPSD Sustainability Assessment Checklist.

9.3.2.5 Concept Development: Determine Supply Chain Dynamics and Engage Supply Chain Management

In each case, the lifecycle stages of the potential offerings were determined as part of the concept development stage. Once the offering to be developed had been finalised, the lifecycle stages and associated supply and value chains were determined. The entire supply chain and supply chain dynamics (SCD) were assessed to determine the most effective target organisation(s) in the chain for SPSD (i.e. company (ies) with control of the product and/or service conception, design and development lifecycle stages) and for implementation up and down the supply chain using Supply Chain Management (SCM). As already described, the case team typically involved companies upstream and downstream in the supply and value chain. An important step in each case was to assess the individual companies' influence and control over lifecycle stages with key sustainability impacts. In eight cases (2, 3, 4 and 6-10), the OEM took responsibility for the overall SPSD implementation as they had control over the main life cycle phases with key sustainability issues. Key suppliers and assemblers were incorporated in the project team to incorporate their input into the design and development stages as relevant to the offering. In cases 2, 3 and 5 end of life recovery operators were also part of the supply chain. Of these eight cases, only one, case 10 involved a selection of their end customers in SPSD. In Case 5 the tier 1

supplier and in Case 1 the tier 2 supplier respectively took responsibility for implementing SPSD on existing product components already manufactured for an existing OEM customer. In these cases the OEM and tier 1 customer and OEM end customer respectively were key contributors to the design and development. Changes to the original product specification resulting from SPSD were tested, finalised and approved by the OEM in both cases as part of the process. In all cases, companies playing different roles in the supply chain worked in conjunction with each other and in particular this involved the company with control over the key lifecycle stages and the product specification.

In all nine cases which went to completion, the offering specification resulting from SPSD was finalised and used as the specification(s) for supply chain companies to provide the required raw materials, components, assemblies and services etc. making up the final offering.

The case experiences highlighted that implementation of SPSD by the company with control over the offering concept and design stages is important to achieving a more sustainable result. In all cases, except 1 and 5, the OEM with control over the concept and offering implemented SPSD. Cases 1 and 5 while developing a more sustainable component of a larger offering, were limited by the specification controlled by the OEM and an end offering with more significant sustainability benefits was not achieved. This lack of control to change the offering specification was identified as a limiting factor in achieving a more sustainable result. The OEM with responsibility for the concept and design of the overall end offering would have been a more suitable target for SPSD implementation in these cases in order to maximise the opportunities for achieving a more sustainable end offering.

The incorporation of a multidisciplinary team especially including key supply chain companies in Concept Development was noted by interviewees in all ten cases as providing more information to enable greater scope in terms of identifying more sustainable options. These cases also noted that the inclusion of supply chain representatives enabled quicker assessment of the feasibility of the options identified than if they were not involved. Interviewees in all cases except 2 and 4 noted that the explicit focus on the supply chain

rather than individual company level and incorporation of supply chain representatives early on in SPSD implementation was a contributing factor to achieving a more sustainable result. Reasons stated for this were:-

- early involvement of supply chain companies facilitated identifying a more sustainable offering which was feasible in terms of all offering criteria (cases 1-3 and 5-10);
- involvement enabled the co-operation and integration necessary to make changes to existing products without adversely impacting end user requirements (cases 3, 4, 6 and 9).

The interviewee from case 4 stated that their suppliers were normally included in their existing product development anyway and therefore, they did not see this as a differentiating factor. As case 2 did not develop an offering, the interviewee did not have a comment on this issue. Interviewees from Cases 1, 3 and 4 noted that involvement of raw material suppliers at the concept development and design stages enabled an increase in the options for disassembly, take back for reuse, recycling and treatment which enabled sustainability benefits to be identified. In addition, the case 3 interviewee noted that inclusion of end of life recovery operators at this stage was a key factor in identifying these options.

The end customer was not involved in all case teams, only cases 1, 5 and 10, hence experiences relating to the importance of involvement of the customer are limited to these cases. Case 10 involved a selection of key end customers. The case 10 interviewee stated that the end customer involvement was beneficial in ensuring all their requirements were incorporated and to gauge how sustainability related changes would be received. Also, as sourcing sustainable timber was a requirement of one of these customers, involvement in the design to meet this requirement was seen by the interviewee as strengthening their business relationship. Cases 1 and 5 where the companies taking responsibility for SPSD were suppliers, noted that involvement of the OEM customer was essential to ensuring their requirements were met and the business was retained, as well as to approving potential changes to the specification. Cases 1 and 5 were unusual in the sense that the OEM is typically the driver for sustainability improvements to products and services. In both these

cases, detailed scoping work was conducted by the suppliers involved on the feasibility of a more sustainable component, in particular to ensure a more cost effective option was likely to result, before approaching their customer about the proposed SPSD implementation. The companies were conscious of bringing a more superior component to the customer in particular in terms of cost benefit as they did not want to adversely impact their existing business with the customer. Both cases 1 and 5 noted that involvement with the OEM in SPSD resulted not only in a more sustainable component, but an enhanced customer relationship and increased resulting business. In cases 5 and 10, interviewees noted that sustainability improvement was seen as a benefit but not a requirement by the end customer, as long as cost and compliance related requirements were met.

Interviewees from cases 1-3 and 5-10 noted that due to the increased involvement of multidisciplinary participants in SPSD, in particular supply chain representatives, effective management internally and across the supply chain was essential to the process. They also stated that the role of the initiating company project manager was key to ensuring this management.

9.3.2.6 Concept Development – Full Sustainability Assessment

The options for providing the functionality required were assessed in terms of TBL sustainability criteria integrated with existing product and/or service criteria in each case. The environmental and then social impacts for each life cycle stage of the proposed offering were assessed first to identify the options which eliminated/reduced adverse environmental and social impacts. Then the feasibility of each environmental and social impact elimination/reduction option was analysed in terms of the following existing criteria (not in order of priority):-

- customer requirements;
- market demand;
- technical feasibility;
- quality;

- compliance with relevant policy/regulatory requirements (e.g. environmental, health & safety and industry specific);
- compliance with relevant industry and technical specifications e.g. CE marking;
- third party product validation options e.g. labels);
- economic issues.

The design that best met all the criteria was considered the most feasible sustainable option.

The full sustainability assessment was conducted using a Life Cycle Thinking approach customised to suit the case. The SPSD Sustainability Assessment Checklist was customised to the case and used as a guide for what to consider in the assessment. This was supported by a variety of tools as relevant to the case. In all cases the assessment covered all lifecycle stages of the offering and the systems in which the offering was to operate in. The SPSD Sustainability Assessment criteria were incorporated with the existing traditional offering criteria in the one offering development checklist. Interviewees from cases 1-3 and 5-10 (those with existing product development systems and defined traditional criteria) thought this was a user friendly way to ensure all criteria relevant to developing the offering were incorporated together. The case 4 interviewee noted the checklist as too formalised and long.

Additional supporting tools to conduct a more detailed assessment were also used in five cases. Where further assessment, and in particular quantification of environmental impacts was required, an abridged Life Cycle Assessment (LCA) was used based on *ISO 14040-43* (ISO, 1999; ISO, 1998; ISO, 2000; ISO, 2000a). This specification for an LCA was used as the basis for a customised abridged LCA in Cases 1, 3-6. An LCA software tool with a database suitable for Ireland, the *LCA Workbench* (Roche et al, 1999), was used in three of these cases. Existing sustainability related specifications relevant to the products and/or services per case were also used as relevant. For example, compliance requirements under the WEEE (EC, 2003a) and RoHS directives (EC, 2003b) were incorporated into the SPSD checklist for the electronics (cases 1 and 2) and ICT (case 3) sector cases. The

specifications defined under environmental labelling schemes were also incorporated. Examples of those used include the *Energy Star* (Case 3), *EU Ecolabel for Personal Computers* (Case 3), EU *Ecolabel for soil improvers* (Case 8), *EU Ecolabel for paints and varnishes* (Cases 4 and 10) and *Forest Stewardship Council* (Cases 4 and 10).

It was observed that the requirement for using different supporting tools was dependant on the case situation. Parameters such as sector; type and complexity of the offering involved; existing information on sustainability impacts and existing product development process used all determined whether additional supporting tools to the SPSD Sustainability Assessment checklist were required. In the revised SPSD approach, consideration of these parameters when deciding which support tools to use is to be incorporated.

Conducting the assessment over the entire lifecycle was noted by interviewees in cases 2, 4-10 as a new concept. The electronics and ICT sector case (1-3) interviewees stated they were already familiar with an Extended Producer Responsibility life cycle approach to some extent mainly through the WEEE (EC, 2003a), RoHS (EC, 2003b) and ELV (EC, 2000a) directives. Interviewees from cases 4-10 stated that difficulty was experienced in adjusting to using this approach by participants. In these cases, consideration of lifecycle sustainability impacts associated with raw material acquisition, consumption and end of life stages were perceived as outside the scope of the product and/or the service provider's responsibility. Also, it was observed that the greater the distance of the location of supply chain activities from the producer's operations, the perception of reduced responsibility increased. The location of supply chain organisations per case are outlined in **Appendix 9**. Cases 1-3 noted less difficulty as these companies had already gone through this learning curve and had accepted this responsibility largely due to the legal and market drivers requiring this in their sectors. This highlights the motivating role of legislation in the use of, at least aspects of, life cycle thinking.

9.3.2.6.1 Integrating Environmental and Social Criteria

In all cases incorporation of environmental and social criteria explicitly in product and/or service development was new in comparison to the existing product development approaches used. In the five cases (1, 3, 5, 8 and 9) with an existing environmental culture (cases 1,5 and 9) based on an ISO14001 EMS) few difficulties were encountered with the incorporation of environmental criteria into the offering development process. In the five cases (2, 4, 6, 7 and 10) without an existing environmental culture, a significant learning curve had to be achieved. However, all cases successfully incorporated the environmental criteria.

In all cases challenges were experienced with incorporating certain social criteria. All companies involved had some elements of social management in place with respect to employee welfare and health and safety. With the exception of the two OEM customers involved in Cases 1 and 5, none of the companies involved had formal TBL Sustainability or Corporate Social Responsibility (CSR) approaches in operation. Social impacts associated with employee and consumer welfare as well as health and safety were incorporated relatively easily as they were part of the companies existing culture. The main reason observed for the limited social impact reduction was that the companies had fewer drivers and were less comfortable tackling social impacts (excluding those already incorporated in the company culture e.g. on site health and safety) compared to environment. This was especially the case for social impacts associated with activities at locations a significant distance away from the company taking overall responsibility for the SPSD implementation. This was relevant to cases 1-3, 5 and 6. Social impact criteria that posed particular difficulty highlighted by interviewees in these cases included those associated with raw material acquisition (e.g. conditions relating to raw material extraction and processing or equitable trading arrangements) and sub contract employee work conditions. Difficulty in obtaining information to fully assess the social impacts for these lifecycle stages was highlighted by these cases. This limited the scope for identifying social benefits to be incorporated. Interviewees in case 8 noted that all relevant social impacts associated with the offering were assessed and no opportunities for social benefit were

identified. It was observed that this was largely due to local acquisition and processing of materials as well as production of the end offering. Interviewees in all cases noted a lack of clear drivers for the offering provider to take responsibility for social issues outside of the companies plant and locality and hence a reluctance to incorporate global social impacts occurring along their supply chains. In these respects, incorporation of social impact criteria in offering development in practice was limited when compared to environment. As limited social impact reduction was achieved, incorporation of these social criteria fully in the SPSD approach requires further testing.

It was observed that in practice certain criteria had a higher priority weighting than others. In particular, customer requirements, market demand, cost and meeting current compliance obligations were high priority criteria. This was an influencing factor for achieving a more sustainable option.

Overall, the process of integrating TBL sustainability criteria with the additional required product and/or service criteria provided a mechanism for identifying the most realistic options, but not always the most sustainable ones. It was observed that the options identified which were the most environmentally sound and socially responsible did not always meet the additional criteria e.g. market demand, cost or technical feasibility. In all cases, a compromise was made in order to develop an offering which met all criteria to some extent. Interviewees in cases 1-3, 5 and 9 highlighted lack of technical feasibility, significantly increased cost and a lack of alternative raw materials as factors which typically prevented a more sustainable offering option being considered further. In all cases this resulted in an offering being developed which was not the most environmentally sound and socially responsible one identified in the sustainability assessment, but was still more sustainable than the existing company's offering. In comparison to this, all completed nine cases developed an offering with environmental benefits. Six of the nine cases developed an offering with social benefits (with the remaining three cases (6-8) determining social impact as unchanged). In terms of economic impact, eight cases developed an offering with economic benefits (with the remaining case 4 determining economic impact as unchanged). Of the completed nine cases, five cases (1,3-5,9-10), resulted in offerings with

environmental, social and economic benefits. Overall, the completed nine cases resulted in more sustainable offerings but not the most sustainable offering identified during the SPSD process. This is a limitation of the SPSD approach in terms of achieving the most environmentally sound and socially responsible option and a statement highlighting this is to be included in the SPSD revision. This limitation is unavoidable at present as meeting the traditional criteria is necessary to product and/or service providers operating in a market economy. Perhaps in a less economically dominated paradigm where value is measured also by non economic parameters and improved technology options are available, the optimum environmental and social benefits could be achieved.

9.3.2.7 Detailed Design and Testing/Prototype

After Concept Development, all cases continued onto the Detailed Design stage. Prototypes were developed in all cases and tested. For cases 3, 4 and 8 testing of the product and service elements plus the PSS combination were incorporated in the design and testing stages. During these stages, unresolvable technical feasibility issues arose for the new energy efficient technology being utilised in the case 2 offering, and the initiating company decided to stop the implementation at this stage. Interviewees in all cases except case 4 stated that the Detailed Design and Testing/Prototype phases were a similar experience to their existing product development approaches. The case 4 interviewee noted that these stages were not as formal and happened earlier on in their existing, informal product development process. The existing testing of prototypes and user trials were rigorous and had specified procedures for cases 1, 3, 5 and 9 in line with their customer and sectoral obligations. These procedures were incorporated without any changes within this SPSD stage. Interviewees from cases 1, 5, 8 and 9 noted that the testing of the final prototypes showed an improved functionality compared to the original product[14] . In particular, the interviewees noted that user trials on the case 9 healthcare packaging and case 5 cartridge reported that the users found the offering functionality improved compared to the previous offering. As one of the criteria in the SPSD Sustainability assessment to be met is the required functionality, it is not unexpected that their required functionality is provided by

[14] These offerings replaced an existing product.

the offering. An improvement in functionality is a bonus, but cannot be directly related to the SPSD process other than that it includes this criterion.

9.3.2.8 Production

After the Detailed Design and Testing/Prototype stages, all cases except case 2 put the offerings into production. For the PSS offerings from cases 3, 7 and 8, this involved production of the product as well as set up for delivery of the service elements. Interviewees from these cases stated this was a change from their previous product development production stages as only products had been produced. All interviewees from these cases noted an increased time and personnel allocation associated with this production phase for setting up the service elements. In light of this feedback, the SPSD approach revision is to include information highlighting these changes may be associated with the production phase where PSS are the offering.

9.3.2.9 Offering Launch and Marketing

After production, all cases except 2 completed the offering launch and marketing stage. Six products and three PSS were launched. As part of the Sustainability Assessment relevant marketing criteria were identified. This included seeing if the sustainability impacts as well as other offering criteria were suitable to market to the offering target customers. As illustrated in **Table 9.3**, interviewees from cases 1 and 3-10 determined the improved sustainability performance of their offering being beneficial to their corporate reputation. Cases 3, 4 and 6 -10 noted the environmental benefit as relevant to the marketing of the offering to end customers. The Case 1 and 5 interviewees noted that while the environmental benefits would be important to their OEM customers, as this was a component they did not see it having marketing potential for end users. While case 2 did not complete this stage of the implementation, the interviewee noted that they did not foresee sustainability benefits for their proposed offering being marketable to their target customers (commercial users of analytic equipment). Interviewees in cases 3 and 5 deemed the marketing of the environmental benefits as relevant only to certain geographic markets

– in both cases the Northern European markets e.g. Scandanavia and Germany. Environmental Product Declarations were identified as relevant to the new offering marketing in four cases. Case 3 achieved the *Energy Star* label, cases 3 and case 8 respectively developed their offering in line with the *EU Ecolabels* for PCs and soil improvers and are considering applying for certification. Interviewees from case 3 and 8 noted that their target customers are unlikely to recognise or require the EU ecolabel, however, the Energy Star label was noted by case 3 as a marketing necessity. Case 8 documents the environmental benefits associated with the PSS clearly on company publications e.g. brochures as well as on the product packaging. None of the interviewees noted social benefits as a marketing advantage.

9.3.2.10 Offering Review

In all cases, the full project team (subject to some individual team members being unavailable), was brought together for the offering review. For each case, feedback on whether the offering had met the required expectations of the relevant stakeholders e.g. initiating company, customers, suppliers were discussed. Interviewees in cases 2 -4, 7-9, in contrast to cases 1, 5 and 9, stated that offering review was not part of their existing product development approach. Interviewees from cases 1, 5 and 9 stated the resulting offering had exceeded their initial expectations in terms of the improvements achieved and met their end customer requirements. These noted that their original expectation had been to meet a legal (case 1), market (case 5) and financial (case 9) driver to improve aspects of their existing products' environmental performance. In addition to this, additional environmental, social, functionality and economic benefits were achieved in the resulting offering. Interviewees from cases 3 and 4 noted that the additional service elements of the final offering were not part of their original expectation and would not have been considered without conducting the Concept Development phase of SPSD. Interviewees in Case 6 and 10 noted that their original expectations and customer requirements were met in their final offering. Case 7 stated their requirements were met but the offering would need some time on the market to test their customers' response fully. Feedback on improvements to the process were noted by the cases and have already been discussed in the sections on the relevant stages.

9.3.2.11 Overall Structure of SPSD approach

The draft SPSD approach used in each case aimed to provide a simplified, flexible, customised implementation process based on a qualitative framework of suggested actions with suitable quantitative supports as necessary. The focus was on a pragmatic, flexible approach consistent with existing business realities. In each case, the SPSD approach was customised to suit the existing culture of the initiating company, sector, product and/or service development system used, offering being developed and existing sustainability management approaches[15].

Interviewees from all cases noted that providing a suggested framework for the SPSD implementation process and supporting information enabled flexibility without limiting the required customisation and creativity. This flexibility in approach was identified by interviewees from cases 1, 3, 5, 6 and 9 (all with existing product development approaches) as key to incorporating and maintaining sustainability criteria in the company's offering development processes. Interviewees from eight cases (1,3 and 5-10) stated that the customisation and integration of SPSD with the company's existing systems prevented SPSD being perceived as an "add on" to the existing business or a burden as distinct from an integral concept. Case 4 noted that the different stages in the process of offering development were too formal for their company culture.

The qualitative nature of the SPSD approach providing a framework of suggested actions backed up by supporting information and further qualitative and quantitative tools as required, was noted as a flexible and effective format by interviewees in all ten cases. However, case 4 noted that they had no previous approach to compare SPSD with. As already described in section **9.5.5** a qualitative, simplified life cycle thinking approach customised to the company culture was used to assess the sustainability impacts. In each case the SPSD Sustainability Assessment checklist was customised and utilised to identify and assess the overall sustainability impacts over all lifecycle phases. Additional qualitative

[15] Where these existed they were environmental management focused with five cases having an existing environmental management culture, three with an ISO14001 accredited EMS).

and quantitative supporting tools were also used in five cases. Overall, the life cycle thinking approach was observed to provide adequate information for developing a sustainable offering without overwhelming the participants with data. As relevant, in the cases that required quantification of certain aspects, abridged LCA was observed as satisfactory to provide the required information. Interviewees from cases 7-10 stated that the customised Sustainability Assessment Checklist was sufficient to identify the sustainability impacts, but required some extra guidance regarding functionality and systems. Based on this feedback, additional information and examples of what could be considered when assessing the functionality and systems interactions are to be included in the revised SPSD approach. The interviewee in case 1 noted that the abridged LCA provided sufficient data but not excessive as had been their previous experience with traditional LCA. However, cases 1 and 3 noted unavailable data on raw material alternatives limited the LCA scope in terms of the alternative material options assessed. Cases 4 – 6 noted the abridged LCA as facilitating the raw materials choices.

In eight cases (1, 3 and 5-10), interviewees stated that the structure of the SPSD implementation based on the SPSD stages were logical and sufficient as a support for developing sustainable products and/or services. Case 2 only went as far as the Detailed Design stage and hence did not make a statement regarding the structure of the implementation process over all stages. Interviewees from cases 1,5 and 9 noted that all stages with the exception of the Planning and Concept Development stages were similar to their existing product development approaches and for developing a more sustainable offering these additional stages enabled a complete approach. They noted the need for additional guidance on the new concepts with which their participants found difficulty e.g. functional based thinking, assessing the impacts associated with the wider systems the offering does/will operate in. Interviewees from cases 3 and 8 stated that without implementing the Concept Development stage, their PSS was unlikely to have been their final offering. Case 4 found the structured stages too formal. Because of the number of steps, iterative nature of the process and multidisciplinary nature of the implementation team, the need to formally document the SPSD process as part of the company offering development approach was noted by cases 1,2,3,5 and 9.

9.4 DISCUSSION

The case study questions to be answered from the case evaluations were the final research questions.

9. Does the implementation using the SPSD approach result in the development of offerings (products, services or PSS) with TBL sustainability benefits (environmental, social and economic)?

Note: offerings with TBL sustainability benefits were defined as preventing, where possible, or minimising adverse sustainability impacts.

10. What are the experiences and views of implementing companies as to the effectiveness and practical use of the SPSD approach as a support for the development of sustainable products and/or services?

The ten cases were evaluated and the results interpreted in terms of the sustainability impacts of the offering resulting and the feedback from the users. The contribution of the SPSD process or not towards developing an offering with TBL sustainability benefits was determined. Overall, application of the SPSD approach to the ten evaluation cases resulted in nine offerings being developed, with one (case 2) not being completed due to unresolvable technical feasibility issues. Of the nine offerings developed, three PSS and six products resulted. Of these nine offerings, five (cases 1,3-5,9-10) had environmental, social and economic benefits. Nine offerings had environmental benefits. Six had social benefits with the remaining three (cases 6-8) having social impact as unchanged. Eight offerings had economic benefits with the remaining case 4 having economic impact as unchanged. Nine offerings were deemed commercially viable and were successfully launched onto the market. Based on these results and the experiences of the companies, it was determined that implementing the SPSD approach did contribute towards developing offerings with TBL sustainability benefits.

The experiences of the companies were that the draft SPSD approach was practically useful and effective as a support for developing sustainable offerings (products and/or services),

but identified a number of areas for improvement. This provided essential feedback for the final revision of the SPSD approach. Business advantages and disadvantages associated with implementing SPSD as a support for developing sustainable offerings were also observed from the experiences.

In terms of the overall structure, the qualitative nature of the SPSD approach providing a framework of suggested actions backed up by supporting information and further qualitative and quantitative tools customised to the company offering, culture and existing offering development systems was seen by the majority of cases as effective. The structure of the SPSD implementation based on the SPSD stages was seen by the majority of cases as logical and sufficient as a support for developing sustainable products and/or services. The minority was one case that found this structure too formal in terms of it having separate implementation stages and requiring integration into the business strategy and systems. This highlights the importance of customising the structure of the process to the company culture.

The experiences identified the following difficulties and areas for improvement:-

- Increased number of participants in the offering development process with associated increased time and costs. This is a negative feature which was not realistically assessed in the evaluation The implications of this increased personnel and associated cost requirement requires further future research.

- Difficulties with concepts such as the focus on functionality and considering alternative options for its provision (by not just products but also services and PSS), consideration of the wider systems the likely offering would operate in and integrating environmental and social criteria into the business strategy were noted as new and challenging concepts in all cases and an important barrier to SPSD implementation, in particular by non environmental and social related business functions if these concepts and the rationale for them could not be understood.

- The requirement for formal documentation of the full process and incorporation of a range of comments highlighted by the cases to make aspects of the process more explicit.

Changes to the SPSD approach based on the feedback from the evaluation cases are listed in **Table 9.4** for each implementation stage.

Table 9.4 Changes to SPSD approach based on Case Evaluations

SPSD APPROACH STAGE	CHANGE
Planning: Management, Organisation and Communication	Include information on the implications for offering development time and personnel e.g. ⇒ Up front increased time commitment is likely, but this could be reduced in subsequent implementations. ⇒ Overall duration of the offering development process (time from concept to market) may not be longer as the communication and participation from supply chain participants early in the process can make it more efficient.
	As part of the overall guidance to customise the process to suit company culture, sector and offering, include the recommendation to customise language and the integration of SPSD into the existing business systems.
Planning: Provision of Information (Introductory)	Amend the business case for SPSD to facilitate understanding and engagement from personnel from different functions – especially non sustainability related functions.
Planning: Strategy Commitment & Integration	As part of the strategy commitment, advise a formal strategy statement incorporating the strategic commitment, as distinct from a less formal agreement as it is more likely to facilitate the required commitment. Translate the strategic commitment formally into performance related business unit goals as a useful way to maintain commitment at an operational and multifunctional level.

Offering Development Concept Development	In order to give additional guidance to facilitate participants regarding what should be considered during Concept Development, further information is to be included on the following:- ⇒ potential issues to be considered when determining how to meet a functionality; ⇒ potential issues to be considered when determining the wider systems interaction the offering will have during its lifecycle. Both of these are to be highlighted as separate steps in the SPSD process Concept Development stage diagram, to ensure they are considered fully. The importance of keeping an open mind and not focusing exclusively on one mode of delivering the functionality (e.g. a product or a PSS) is to be made more explicit in the approach.
	In the recommendation that SPSD should be implemented by the company with design control over the offering, include that a more sustainable offering is likely when applying SPSD to the overall end offering as distinct from focusing on components of the overall offering.
	When deciding whether and which additional supporting tools to the SPSD Sustainability Assessment checklist are required consider parameters such as sector; type and complexity of the offering involved; existing information on sustainability impacts and existing product development process used.
Production	Include information highlighting that increased time and personnel may be required for the production stage where a PSS offering is put into production for setting up the service elements.

Based on the results and feedback from the case evaluations, as well as one of the SPSD implementation criteria being the need for a simple, flexible framework, which could be suitably customised[16], the SPSD process was documented as a guide as a means of formalising the approach and communicating it and is provided in **Chapter 10.**

[16] For further information see **Chapter 6.**

The case evaluation results provided information on the contribution of the SPSD approach to developing sustainable offerings and other influencing factors that impacted the resulting sustainability benefits and the extent to which these were achieved. An analysis of this is discussed in **Chapter 11** as part of the overall research findings.

9.5 SUMMARY

This chapter described the case study evaluation of the draft SPSD approach based on its implementation in ten cases. Based on the results and feedback received from the evaluation the final version of the SPSD approach is presented as a guide in **Chapter 10**.

CHAPTER 10 SPSD GUIDE

10.1 INTRODUCTION TO THE SPSD GUIDE

The final version of the SPSD implementation process is set out in the form of a "Guide for Developing Sustainable Products and/or Services in Industry" in the following pages. The referencing and formatting of the guide is independent from the main body of the thesis as it has been designed as a standalone document.

Guide for Developing Sustainable Products and / or Services In Industry

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This document is printed on Evolve paper made from 100% post consumer waste (Grade C), non chlorine bleached and de-inked.

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Ongoing Information Supports	
Sustainable Products and/or Services Database of information resources	
Legal compliance obligations	
Support tools	

[1] The page numbering of the guide has been ordered to fit sequentially within this thesis.

I INTRODUCTION

1.1 EXECUTIVE SUMMARY

While the volume and diversity of products on the market today can benefit our quality of life, their production and consumption can have a significant adverse impact on the environment. This impact is recognised as a contributing factor to many of the environmental problems evident in today's world e.g. climate change, waste generation and resource depletion. Adverse ethical and social impacts can also be a feature of production and consumption e.g. child labour, inequitable distribution of resources and trading policies. In our globalised, "CNN" world, these adverse environmental and social impacts are an increasing concern for business, consumers and policy makers alike.

For these reasons, there are increasing legal, market and financial drivers for industry to manage the environmental and social impacts of their activities, products and services and demonstrate good sustainability performance. Sustainable organisations need to measure and account for their performance not only in traditional economic terms (the bottom line) but also in social and environmental terms creating the now recognised Triple Bottom Line performance measure for business. Company performance is increasingly judged not just by its activities and the products and/or services they provide, but by also by the impacts they have on the environment and social well being.

This is a guide for **Sustainable Product and/or Service Development (SPSD)**. It is aimed at producers of products and services in industry. It provides a practical, flexible guide and supporting materials for developing sustainable products and/or services. It provides a template for incorporating environmental and social issues into the design and development of all offerings whether they are products, services or combinations. It is designed to integrate with existing business systems and to give companies an opportunity to develop products and/or services which are environmentally sound, socially responsible and economically successful.

1.2 INTENDED AUDIENCE

The intended audience is companies, practitioners and other stakeholders requiring guidance in the process of designing, developing and bringing to market sustainable products and/or services.

1.3 HOW TO USE THIS GUIDE

This guide provides a flexible, generic, qualitative framework of suggested actions for designing and developing sustainable products and/or services. As such, it can be applied to any industry sector.

As the process of developing sustainable products and/or services differs not only between sectors, but also between companies, products and /or services, the intention is that it is suitably customised in line with an organisations individual circumstances. Factors determining customisation include the existing culture of the company, sector, product and/or service development system used, offering being developed, business systems and existing sustainability management approaches used (e.g. Environmental Management Systems) (if any). The recommended actions in the guide should be incorporated with existing offering development approaches used, or as a standalone guide for those companies without an existing offering development system.

Companies can move through the different implementation stages at different speeds and with different emphasis depending on their individual circumstances and level of experience regarding developing sustainable offerings.

The guide may be supported by suitable existing qualitative and quantitative tools (e.g. assessment, measurement, benchmarking, reporting, communications etc.) as required. A range of supporting materials and tools are provided as part of the guide to facilitate this.

The guide is divided into four parts. **Part I** provides introductory information to facilitate use of the guide. **Part II** describes the business case for developing sustainable products and services in industry. The implementation process for SPSD is described in **Part III**. This is a step by step guide of suggested actions for developing more sustainable offerings backed up by a range of supporting materials to be used during the implementation. The supporting materials are included in **Part IV** of the guide and include training materials e.g. presentations and handouts, supporting tools, information supports e.g. databases and checklists. Part IV of the guide is best used online rather than in hard copy and is included on the attached CD ROM. To use open the file "read me.txt" on the CD ROM.

1.4 TERMS AND ACRONYMS

The topic of developing sustainable products and services has its own set of terms and acronyms. Those included in the guide are in this list. While it is important to understand the terminology associated with this topic, one of the key aspects of this guide is to minimise jargon and use recognised business language as much as possible.

Acronyms	Terms
CE	Concurrent Engineering
DfE	Design for Environment
EC	European Commission
EEE	Electrical and Electronic Equipment
EMS	Environmental Management System
ELV	End of Life Vehicles
EPR	Extended Producer Responsibility
EU	European Union
EuP	Energy Using Products
IPP	Integrated Product Policy
ISO	International Standards Organisation
ICT	Information Communications Technology
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
MNC	Multinational Corporations
OEM	Original Equipment Manufacturer
POEMS	Product Orientated Environmental Management Systems
PSS	Product Service System
RoHS	Restriction of Hazardous Substances
SC	Supply Chain
SCD	Supply Chain Dynamics
SCM	Supply Chain Management
SD	Sustainable Development
SMEs	Small and Medium Sized Enterprises
SPSD	Sustainable Product and Service Development
TBL	Triple Bottom Line
UNEP	United Nations Environment Programme
WEEE	Waste from Electrical and Electronic Equipment

1.5 ACKNOWLEDGEMENTS

"If I have seen further it is by standing on the shoulders of giants".
Sir Isaac Newton, 1676

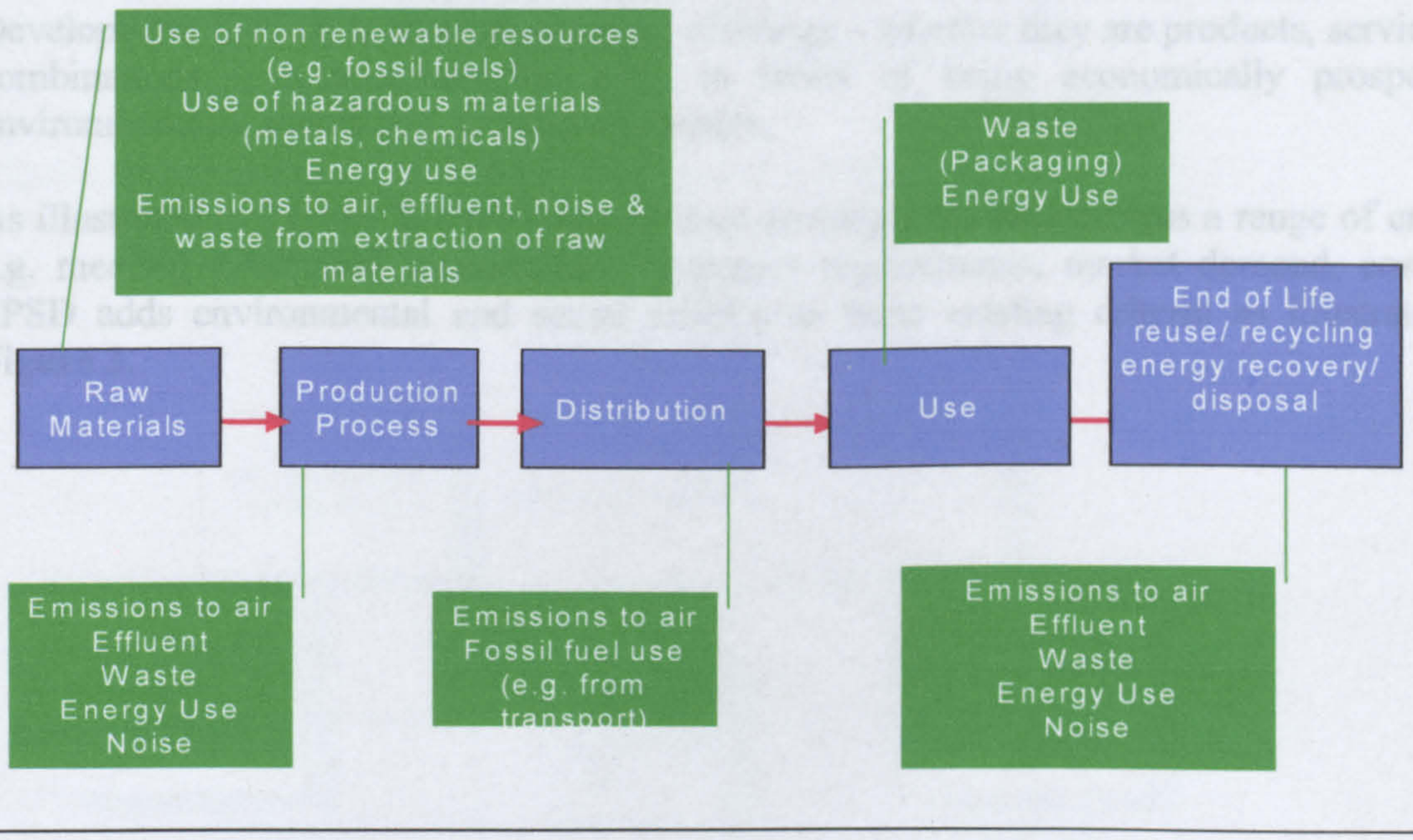
This guide is based on the assessment of existing approaches relevant to developing sustainable products and/or services. It builds on aspects of these approaches and adds new elements to provide an industry support for developing sustainable offerings. It has been developed as part of a PhD research project at the Environment Policy and Management Group, Department of Environmental Science and Technology, Imperial College London.

PART II BUSINESS CASE FOR DEVELOPING SUSTAINABLE PRODUCTS AND SERVICES

2.1 WHY DEVELOP SUSTAINABLE PRODUCTS AND/OR SERVICES?

While products can greatly improve our quality of life, their production and consumption can have adverse environmental and social impacts. Over the lifecycle of a product its material consumption, and end-of-life issues in particular, can cause significant environmental degradation. Some examples of the typical environmental impacts associated with typical product lifecycle stages are illustrated in **Figure 1**.

Figure 1 ENVIRONMENTAL IMPACTS OVER THE LIFE CYCLE



Adverse ethical and social impacts can also be a feature of production and consumption e.g. child labour, inequitable distribution of resources and trading policies. Traditionally, the focus for industry has been on reducing the environmental impacts of production processes. However, this responsibility is being extended, and manufacturers are now required to reduce the environmental impacts of both processes and products. This approach is known as Extended Producer Responsibility (EPR) as it extends the manufacturers responsibility from managing the environmental issues of the production process to the entire lifecycle of the product – from raw materials, production, distribution, consumption to end-of-life and

beyond. On the social side, there is increasing pressure for industry to manage their social impacts throughout their supply chains and demonstrate good social performance. Sustainable organisations need to measure and account for their performance not only in traditional economic terms but also in social and environmental terms. Company performance is increasingly judged not just by its activities and the products and/or services they provide, but by also by the impacts they have on the environment and social well being. Overall, policies, legislation market and financial initiatives to reduce the sustainability impacts of products are increasing and impacting current thinking on product and service development. For information on legal and market drivers see Part IV on CD ROM.

2.2 WHAT IS SUSTAINABLE PRODUCT AND/OR SERVICE DEVELOPMENT?

Product and service development is well understood. Sustainable Product and/or Service Development (SPSD) is about developing offerings – whether they are products, services or combinations - in a sustainable way, in terms of being economically prosperous, environmentally sound, and socially acceptable.

As illustrated in **Figure 2**, traditional product development incorporates a range of criteria e.g. meeting a required functionality, customer requirements, market demand, cost etc. SPSD adds environmental and social criteria to these existing criteria as illustrated in **Figure 3**.

Figure 2 Traditional criteria normally considered in product development

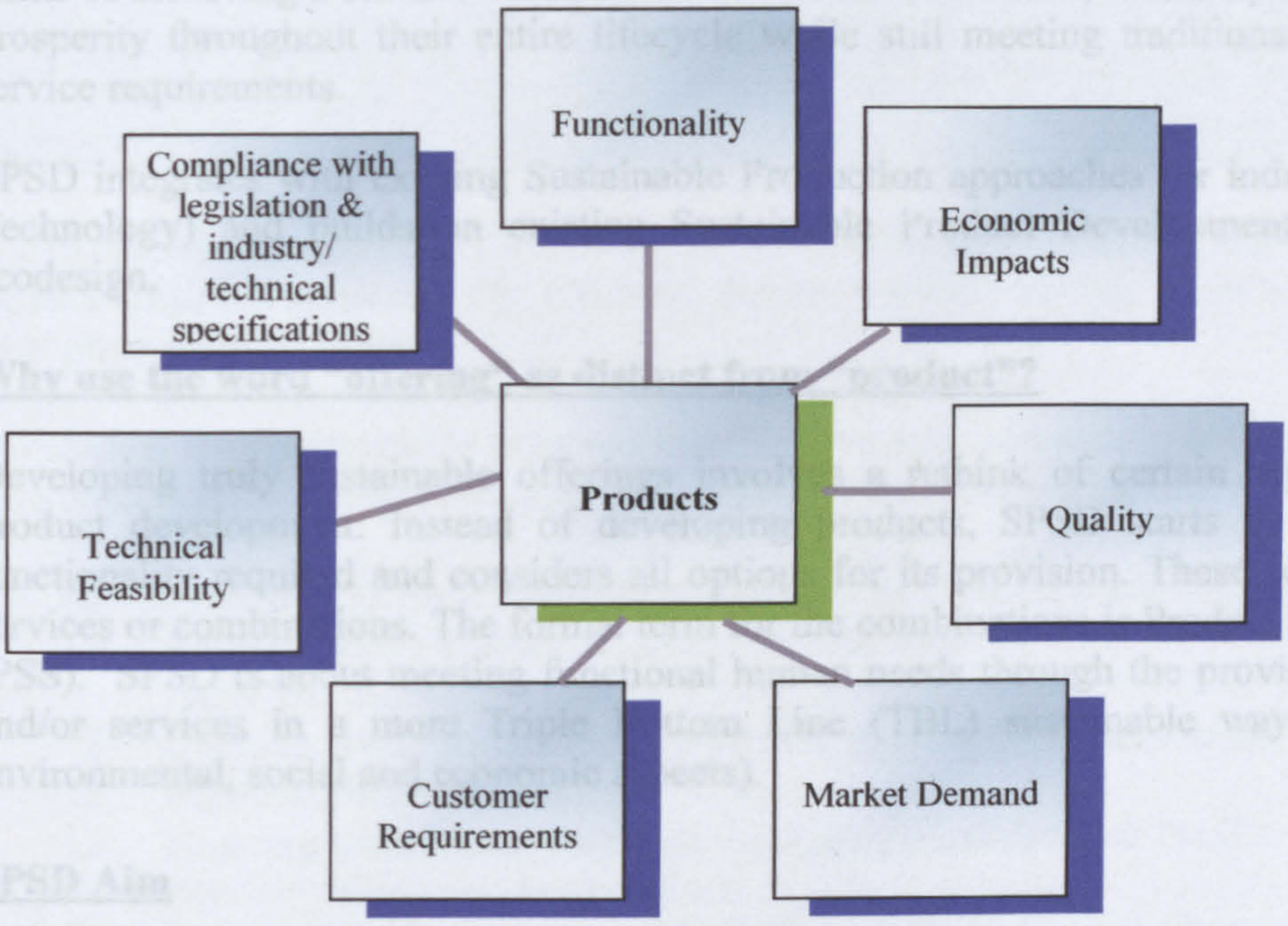
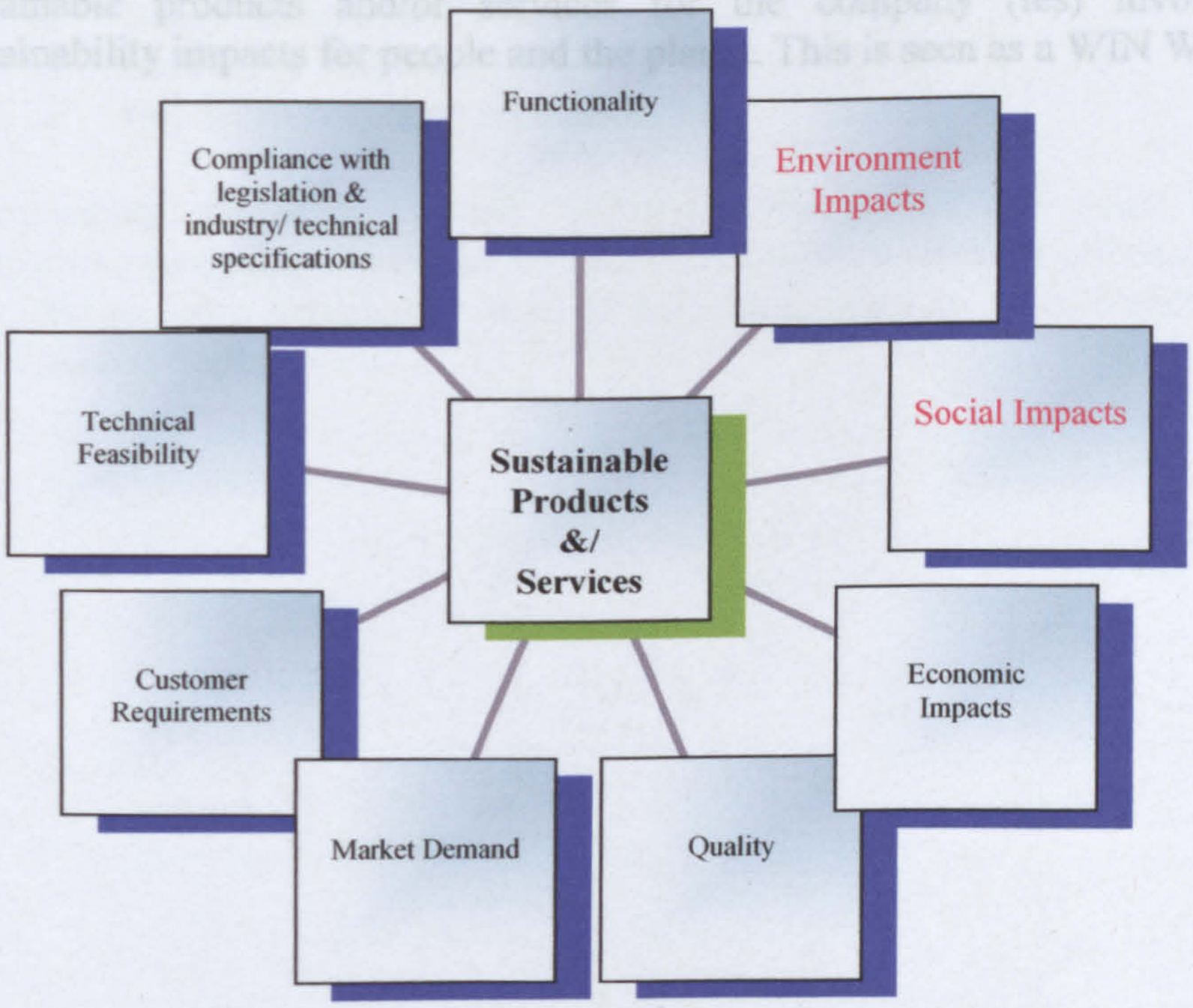


Figure 3 Criteria for Developing Sustainable Products &/ Services



SPSD is the process of developing products and/or services which are more sustainable in terms of achieving a balance between environmental protection, social equity and economic prosperity throughout their entire lifecycle while still meeting traditional product and/or service requirements.

SPSD integrates with existing Sustainable Production approaches for industry (e.g. Clean Technology) and builds on existing Sustainable Product Development initiatives e.g. ecodesign.

Why use the word "offering" as distinct from "product"?

Developing truly sustainable offerings involves a rethink of certain aspects of current product development. Instead of developing products, SPSD starts by identifying the functionality required and considers all options for its provision. These could be product, services or combinations. The formal term for the combinations is Product Service Systems (PSS). SPSD is about meeting functional human needs through the provision of products and/or services in a more Triple Bottom Line (TBL) sustainable way (i.e. balancing environmental, social and economic aspects).

SPSD Aim

The goal of SPSD is to produce offerings, be they products and/or services, that are sustainable (in environmental, social and economic terms), achieve their required functionality and fulfil traditional criteria. The ideal result of the SPSD process is more sustainable products and/or services for the company (ies) involved and reduced sustainability impacts for people and the planet. This is seen as a WIN WIN WIN scenario.

2.3 EXPECTED OUTCOMES AND BUSINESS BENEFITS

The expected outcome of implementing SPSD is innovative offerings that meet a required functionality, are economically efficient, environmentally sound, socially acceptable and meet other required criteria.

Developing more sustainable offerings can improve your company's profitability as well as environmental and social performance. Direct business benefits include:-

- ❑ Cost savings from reduced raw material and resource consumption;
- ❑ Reduced waste collection, treatment and disposal costs especially in the case of hazardous waste;
- ❑ Improved offering functionality better meeting customers needs;
- ❑ Improved health and safety
- ❑ Ongoing compliance with legal obligations and reduced liability associated with poor environmental performance;
- ❑ Improved relationships with key stakeholders e.g. customers, suppliers, shareholders, regulatory authorities and local communities;
- ❑ Improved opportunities for marketing features leading to increased sales;
- ❑ Expanding market opportunities;
- ❑ Improved competitiveness;
- ❑ Capability building;
- ❑ Improved corporate reputation.

Incorporating sustainability into offering development can offer a new source of competitive advantage. Considering more sustainable modes for offering provision may not only lead to more sustainable ways of delivering solutions to customers but may identify new business opportunities.

PART III –SUSTAINABLE PRODUCT AND/OR SERVICE DEVELOPMENT (SPSD) IMPLEMENTATION STEPS

3.1 PROCESS SUMMARY

The SPSD implementation process is designed to provide a framework for implementing SPSD throughout the complete lifecycle of a product and/or service and the associated supply chain.

The SPSD process is designed to identify, assess and implement the options for maximising environmental and social performance in product and/or service development while still fulfilling traditional product and/or service criteria.

The overall stages in the SPSD implementation process are based on a modified version of the typical product and/or service development processes used in industry and in particular that advocated in *ISO/TR 14062 Environmental Management – Integrating environmental aspects into product design and development* [2]. This is to facilitate ease of integration with existing offering development approaches used in industry. These stages are illustrated in **Figure 4.**

The Planning Stages are designed to get the set-up right for the offering development. The offering development incorporates concept development through to offering launch. An offering review stage is included to get feedback on the success of the final offering.

The stages can be iterative and are designed to provide a flexible framework of suggested actions to include in order to develop sustainable products and/or services effectively.

In addition to specific aspects focusing on the design and development of a more sustainable offering, guidance on other issues e.g. organisation, management and communications and supply chain management are included to ensure an effective implementation process. Each stage is described in the following **sections 3.2-3.3**. For each stage, the following is defined:-

- ❑ the aim;
- ❑ key activities;
- ❑ outcome;
- ❑ supports included in the guide to be used in the stage.

[2] ISO /TR 14062 Integration of Environmental Aspects into Product Design and Development, ISO, Switzerland, 2002

Figure 4 Recommended Stages in the SPSD Implementation Process

PLANNING

1 Organisation, Management & Communication

2 Provision of Introductory & Ongoing Information

3 Strategic commitment and integration into existing business systems

OFFERING DEVELOPMENT

1 Concept Development

- Functionality
  - ⇒ Starting with the function to be provided;
  - ⇒ Considering all the options for meeting the functionality – services, products and PSS;
  - ⇒ Considering the wider systems interactions;
- Determine life cycle stages;
- Assessing the sustainability impacts;
  - ⇒ Integrating TBL sustainability criteria with traditional product and/or service criteria;
- Determine the Supply Chain Dynamics
  - ⇒ Determine optimum target for SPSD and other roles;
  - ⇒ Supply Chain Interaction and Co-ordination (Supply Chain Management);
- Full Sustainability Assessment.

2 Detailed Design
3 Testing/Prototype
4 Production
5 Offering Launch and Marketing
6 Offering Review

Application

The approach should be used to develop a new sustainable offering from its conception onwards or it can be applied to existing products and/or services. However, as greater sustainability benefits are likely if applied at conception, when there is only a functional need to be met and no decision on how it is to be provided has yet been made, application from conception onwards is a key part of the process. To start with an existing product and/or service and apply the remaining aspects of the SPSD process can be done, but would miss a crucial stage and potentially significant opportunities for sustainability improvements.

3.2 PLANNING

IMPLEMENTATION STAGE: PLANNING	
AIM	The planning stage is designed to prepare the set-up for the offering development stage.
KEY ACTIVITIES	Guidance under the following four headings is included. These can be followed iteratively as required. Go to each section for the recommended actions. **3.2.2 Organisation, Management and Communication** **3.2.3 Provision of Introductory and Ongoing Information** **3.2.4 Strategic Commitment and Integration into Existing Business Systems**
OUTCOME	Set-up under each of the above headings to enable an effective offering development stage.
SUPPORTS	Introductory Information Training Module (on CD ROM) Ongoing Information Supports (on CD ROM) • Sustainable Products and/or Services Database of information resources • Legal compliance obligations • Industry schemes, voluntary standards and labeling • Support tools

3.2.2 ORGANISATION, MANAGEMENT AND COMMUNICATION

This section provides guidance for ensuring effective organisation, management and communications both internally and across the offering supply chain. This encompasses issues relating to the initial set up, responsibility and resource allocation, expertise, and language use.

Initial Set up

- ❑ Within the initiating company, hold initial scoping meetings to discuss the proposed offering development. This should include identification and accessing of required information, developing objectives, a plan, allocating budgets/costs and identifying the likely development team members.

Which company in the supply chain should take overall responsibility for SPSD implementation?

- ❑ The company with control over the conception and design of the offering in question should take overall responsibility for the offering's development. This is typically the Original Equipment Manufacturer (OEM).
- ❑ The focus of the implementation should ideally be the end offering being considered. Applying SPSD to sub components of an overall offering can give sustainability improvements, but these are limited to those possible by applying SPSD to the end offering or wider system it interacts with. For example, it is more effective to design a more sustainable house than to design more sustainable insulation or boilers. While individually sustainability improvements can be made to the insulation and boilers, considering the end offering as a whole can give greater opportunities for a more sustainable house

Allocating Responsibility

Project Champion

- ❑ Within the company taking overall responsibility, an overall champion/project manager for the complete SPSD implementation process should be allocated. Ideally this individual will be from a sustainability related (where this exists), environmental, product and/or service development function within the existing company structure.

Offering Development Team

- ❑ All stakeholders relevant to the offering development should be identified and incorporated in the development team. Suggested stakeholders for the development team include:-

⇒ representatives from each key business function (to include product and/or service design and development, environment, quality, health and safety, operations, purchasing, finance, marketing) in the company taking overall responsibility for the SPSD implementation;

⇒ suitable representatives from supply/value chain companies upstream and downstream (e.g. raw material suppliers, assemblers, component manufacturers, service providers, retailers, end of life recovery, reuse, recycling, treatment/disposal companies);

⇒ customers (representation from a selection of customers to include Business to Business (B2B) in particular, Business to Trade (B2C), Business to Consumer (B2C) ;

⇒ external expertise (to include SPSD expertise and industry expertise relevant to the offering being developed, as required).

- ❑ The responsibility for specific elements of the process may be allocated to supply/value chain stakeholders as appropriate.

- ❑ The identification, engagement and effective management of all relevant stakeholders at an early stage in the offering's development are key elements of SPSD. The timing of this is dependant on identifying all the relevant stakeholders and may vary depending on the situation. For example, if there is an existing product and/or service some of the likely stakeholders will be identifiable e.g. customer, supply chain companies etc. If it is a new offering to be developed, the stakeholders will need to be identified. Stakeholders may also be identified at different stages in the process and should be incorporated as required.

- ❑ Once the company taking overall responsibility is agreed, a meeting(s) with the CEO and senior management should take place to provide suitable introductory information (section 3.2.3) and agree a strategic level commitment (section 3.2.4) to developing sustainable products and/or services, as relevant to the situation.

- ❑ Once the key project team members are identified, an initial meeting(s) should be held with the entire team to communicate the aims, deliverables, plan, and decide about team members and their roles. The introductory information module (section 3.2.3) should be included in this session. This meeting should include the CEO/senior management representative as relevant, and illustrate the strategy level business commitment to the development of a sustainable offering. The aim of this initial meeting(s) is to communicate information, inspire, identify potential problems, illustrate commitment from the top and get buy in from the participants early on.

- ❑ In the offering development stage, the development team should be involved at all stages of concept development to provide all the multidisciplinary input required to identify the most sustainable offering which meets all requirements. From detailed design onwards the members of the development team can be incorporated on an as needs be basis.

- ❑ As the offering development stages can be iterative, regular status meetings with the development team are advised. This is to discuss progress and, in particular, changes in direction and potentially the need to rethink previously identified options etc.

SPSD Expertise

- While this guide is comprehensive, including expertise relevant to developing sustainable products and/or services as part of the team is strongly recommended to facilitate and guide the SPSD implementation process. Where internal expertise is not available, external expertise should be used as long as they work closely with the project champion and team to transfer expertise as relevant into the company (ies) involved to enable ongoing SPSD activities.

Using Business Language and Minimising Jargon

- The implementation process should be customised in line with the existing culture of the company, sector, product and/or service development system used, offering being developed, business systems and existing sustainability management approaches used. This should include customising the language/terminology used. New concepts and terminology are associated with incorporating sustainability criteria into offering development. To facilitate communication, understanding of concepts and avoid barriers being created by the use of new concepts and terminology, the language used to communicate these terms should be carefully considered based on the company(ies) cultures and other stakeholders involved. New SPSD related terms will be introduced to the offering development team in the provision of Introductory Information (see section 3.2.3) stage of the implementation. Where these terms are new or pose difficulties the use of jargon should be minimised and where possible "translated" into the relevant business language of the companies and industry sector involved. The use of recognised business language and misimising jargon should be considered as appropriate to facilitate effective communication during the implementation in particular in light of the multidisciplinary business functions and range of stakeholders involved.

- In this guide, 

is used to denote the introduction of SPSD related terminology which is highlighted in red and is followed by an explanation.

Resources: Time and Personnel

- For those incorporating sustainability in their offering development in line with the SPSD process, increased personnel and time resources are likely in light of the involvement of key stakeholders within the company and the offering supply and value chains. An upfront increased time commitment is likely. This is expected to be reduced in subsequent implementations, once the process is embedded.

- The overall duration of the offering development process (time from concept to market) will vary based on a number of factors e.g the offering, sector, company culture and experience in offering development. Experience shows that the offering development time may not necessarily be longer than standard product development

processes as the communication and participation from supply chain participants early in the process make it more efficient overall. Of all the implementation stages, Concept Development is likely to require the most time investment.

3.2.3 PROVISION OF INTRODUCTORY AND ONGOING INFORMATION

Introductory as well as ongoing information supports are recommended at relevant stages of the implementation process. This information should be customised to suit the situation e.g. sector, company (ies) involved, existing or likely product and/or service as well as the existing knowledge base of the company(ies) involved. Examples of key information requirements include:-

- information and knowledge relating to the business case,
- assessing the environmental, social and economic impact of products and/or services, compliance requirements,
- technical specifications from suppliers and customers,
- technical innovations and market developments.

Introductory Information

Once a company initially commits to developing sustainable products and/or services, a key step in the SPSD implementation is to provide relevant introductory information to ensure all parties have a comprehensive understanding of the background information. The introductory information is designed to cover the following issues:-

Introductory Information Module

1. The business case for developing sustainable products and/or services;
    a) What is a sustainable product and/or service?
    b) Why develop sustainable products and/or services?
    c) What are the legal, market and financial drivers?
    d) Expected outcome and business benefits
2. A description of the SPSD process
3. How does SPSD fit within my existing sustainability, environmental, product and/or service development and other business systems?
4. Potential pitfalls;
5. Case examples relevant to the sector and offering likely to result;
6. Information resources;
    a) Introduction to the *Sustainable Products and/or Services Database* of information resources.

- ❑ An introductory information session(s) should be given to disseminate this information to the full multidisciplinary development team plus the CEO and senior management of the company taking overall responsibility for SPSD implementation as early in the implementation as possible. An Introductory Information Module incorporating these topics in included in Part IV of this guide (on CD ROM). This includes a sample Powerpoint presentation incorporating this information which can be customised and used for giving the introductory information session.

- ❑ The function of the Introductory Information module is to inform as well as inspire companies with innovative case examples. A lack of understanding of the rationale, and in particular the business case for developing sustainable offerings can be a significant barrier to a successful implementation. For this reason, the introductory information session should be comprehensive (at least including the topics suggested), be customised to the company, sector and likely offering and occur as early as possible in the implementation process.

- ❑ The audience for the information provision should be as representative as possible, ideally incorporating the most senior representative (e.g. CEO), senior management and representatives from all business functions/units within the company taking responsibility for the implementation. Once all the stakeholders in the offering development team are identified, a similar information provision session should be given to this team.

- ❑ The Introductory Information should ideally be given by a senior team member with appropriate SPSD expertise (either internal or external to the company).

Provision of Ongoing Information

As required, information supports should be used on an ongoing basis throughout the SPSD implementation process. These supports should be customised to suit the situation (e.g. company (ies), sector, product and/or service involved). The following ongoing information supports are included in Part IV of this guide (on CD ROM):-

- ❑ Sustainable Products and/or Services Database of information resources;
- ❑ Legal compliance obligations;
- ❑ Industry schemes, voluntary standards and labels;
- ❑ Support Tools.

These supports are provided as a starting point and should be customised and used selectively as relevant to the offering being developed.

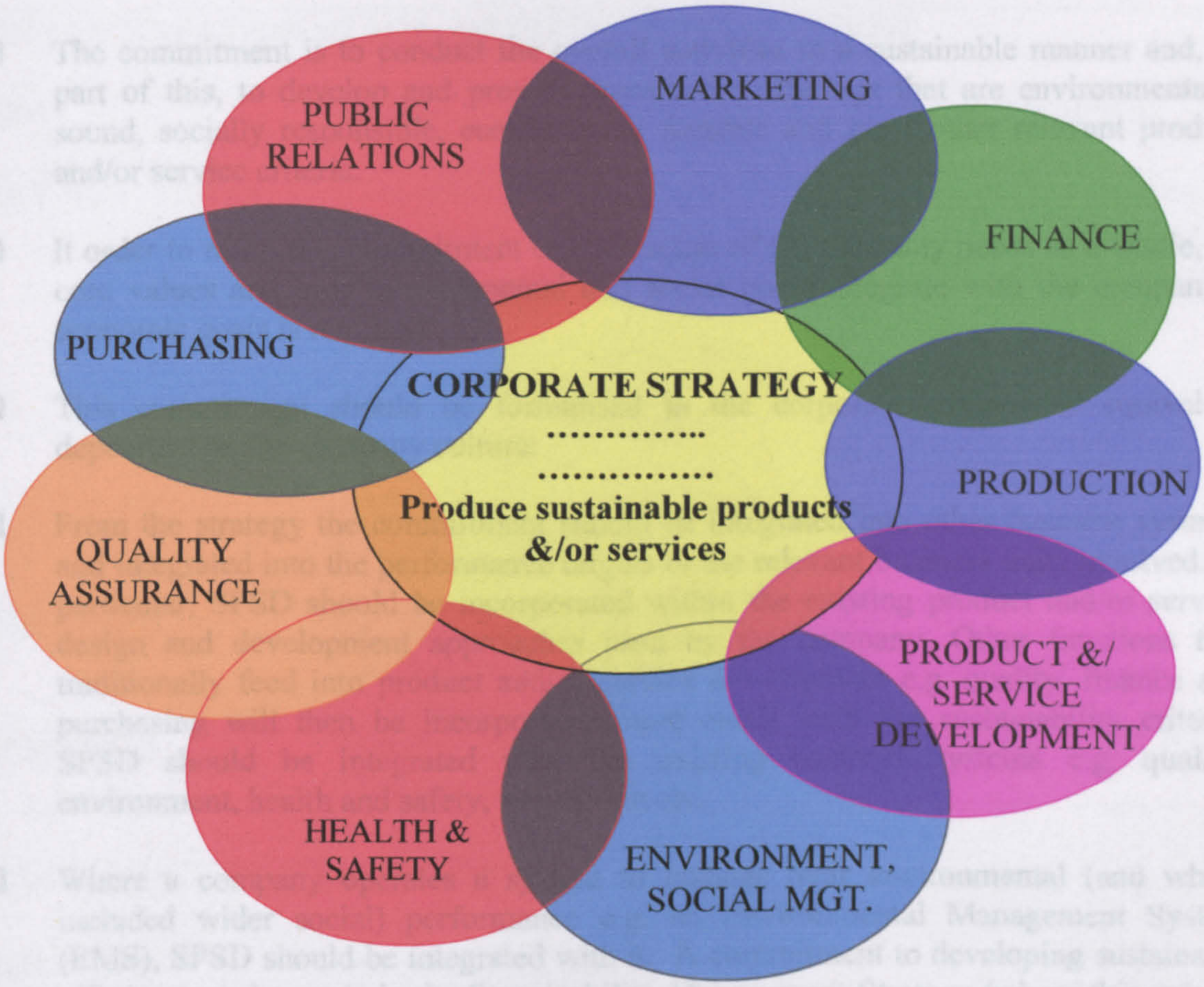
Other ongoing information will include:-

- Information from supply chain companies e.g. data on raw materials, components, assemblies etc.;
- Data on alternatives (e.g. materials, energy sources) from existing data sources e.g. suppliers, databases etc.;

3.2.4 STRATEGIC COMMITMENT AND INTEGRATION INTO EXISTING BUSINESS SYSTEMS

A key planning stage is to make a commitment to developing sustainable products and/or services at the most senior level and integrate it into the business goals. **Figure 5** illustrates a proposed structure for this integration.

Figure 5 Integrating SPSD into corporate systems



The requirement to conduct the company activities in a sustainable manner and produce sustainable products and/or services, as relevant, should be integrated as one element of the existing corporate strategy (illustrated in the central sphere). From here it is a core business criterion that can be incorporated into all other business functions (finance, marketing, quality, production, environment (and social management if it exists) health & safety, purchasing etc.) for overall sustainability performance improvement. Integration of SPSD in these existing systems is to achieve an operational framework to build on the strategic commitment Overall, by integrating sustainability in the corporate strategy and business functions it is integrated as a core element necessary for improving business performance rather than a stand-alone programme. The intention of the strategic commitment from the

top downwards is to facilitate buy in and co-operation among the range of business functions involved in the offering design and development process.

Guidance on making this strategy and operational commitment is included in the bullets below.

- ❑ The commitment is to be made by the company taking responsibility for the SPSD implementation at CEO and senior management level dependant on the company culture.

- ❑ The commitment is to conduct the overall activities in a sustainable manner and, as part of this, to develop and provide sustainable offerings that are environmentally sound, socially responsible, economically feasible and meet other relevant product and/or service criteria.

- ❑ It order to make this commitment consideration of the company needs as a whole, its core values and how environmental and social goals integrate with the company's economic goals is required.

- ❑ This commitment should be formalised in the corporate strategy or equivalent dependant on the company culture.

- ❑ From the strategy the commitment should be integrated into other business systems and integrated into the performance targets of the relevant business units involved. In particular, SPSD should be incorporated within the existing product and/or service design and development approaches used by the company. Other functions that traditionally feed into product and/or service development e.g. quality, finance and purchasing will then be incorporated more easily with the sustainability criteria. SPSD should be integrated with the existing business systems e.g. quality, environment, health and safety, production etc.

- ❑ Where a company operates a system to manage their environmental (and where included wider social) performance e.g. an Environmental Management System (EMS), SPSD should be integrated with it. A commitment to developing sustainable offerings can be made in the Sustainability Management Strategy (where this exists), but more likely in the EMS Environmental Policy Statement followed up with specific Environmental Objectives and Targets relating to developing sustainable products and/or services This goes beyond incorporating a strategic commitment into the Environmental Policy alone.

3.3 OFFERING DEVELOPMENT

Having completed the planning stage, the offering development is the next stage in the SPSD implementation.

IMPLEMENTATION STAGE: OFFERING DEVELOPMENT	
AIM	Design, develop and bring to market a sustainable offering
KEY ACTIVITIES	The offering development process incorporates the following activities to be followed consecutively with some iteration as required. Go to each section for the recommended actions. 3.3.1 Concept Development 3.3.2 Detailed Design 3.3.3 Testing/Prototype 3.3.4 Production 3.3.5 Offering Launch and Marketing 3.3.6 Offering Review
OUTCOME	• Sustainable offering on the market • Feedback of offering development process to improve future offering developments.
SUPPORTS	SPSD Sustainability Assessment Checklist (see section 3.4) Support Tools (see Part IV on CD ROM)

3.3.1 CONCEPT DEVELOPMENT

Aim

In Concept Development the potential options for providing the offering are identified and assessed to determine how to maximise environmental and social benefits which are still feasible in terms of other offering requirements e.g. cost, technical feasibility, market demand etc.

Rationale

At the concept stage, the possibilities to maximise sustainability performance are the highest. 80% of the environment and economic impacts that will occur throughout a product and/or services life are determined at this stage[2]. This is the stage to identify the

[2] ECOLIFE (2002), EcoDesign Guide : Environmentally Improved Product Design Case Studies of the European Electrical and Electronics Industry, ECOLIFE Thematic Network, July 2002

opportunities for maximising environmental, social and economic performance. The method of provision of a function e.g. a service, product or some combination has significant implications for environmental and social impacts as well as potential business opportunities in terms of new ways to meet customer needs e.g. value added services and associated profit sources.

Key Steps

The steps to be incorporated in Concept Development include the following.. :-

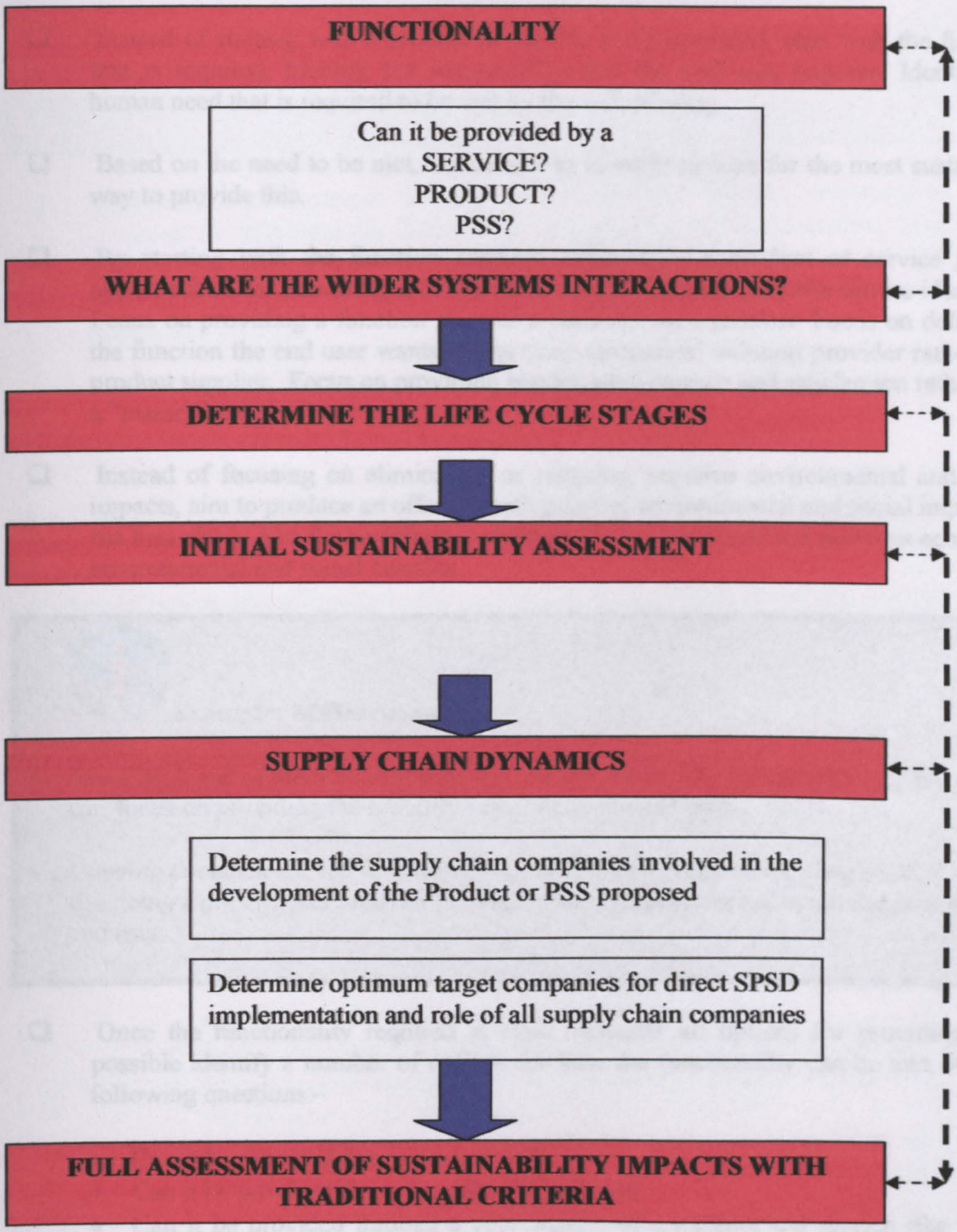
- Determining the most sustainable way to provide the functionality (section 3.3.1.1) required.
- Consideration of the wider systems (section 3.3.1.2) in which the offering currently/will operate in throughout its entire lifecycle.
- Identification of all potential product and/or service lifecycle stages (section 3.3.1.3).
- Sustainability assessment (section 3.3.1.4) of the environmental and social issues likely to be associated with all lifecycle stages for the proposed options to meet the functionality.
- Finalise the Supply Chain Dynamics and maintain Supply Chain Management (section 3.3.1.5)

The key steps in Concept Development are illustrated in **Figure 6**. These are iterative elements with some being revisited and repeated throughout the process. Brainstorming sessions with the offering development team should be conducted to consider these issues. Go to the sections for the recommended actions under each step.



Concept Development is not normally included in traditional product development approaches and the activities will be new to most of the offering development team. For this reason the explanation and rationale for inclusion of these activities is incorporated in the Introductory Information Module (see Part IV on CD ROM). All team members should have received this training prior to Concept Development (see section 3.2.3)

Figure 6 SPSD Process – Concept Development Stage



3.3.1.1 Functionality

- ❑ Instead of starting with a product or service to be provided, start with the function that is required. Identify the functionality that the end user requires. Identify the human need that is required to be met by the end offering.

- ❑ Based on the need to be met, brainstorm to identify options for the most sustainable way to provide this.

- ❑ By starting with the function required rather than a product or service greater opportunities for providing it in the most sustainable way possible can be identified. Focus on providing a function to meet a need not on a product. Focus on delivering the function the end user wants, being your customers' solution provider rather than product supplier. Focus on providing results, performance and satisfaction rather than a "material product".

- ❑ Instead of focusing on eliminating or reducing negative environmental and social impacts, aim to produce an offering with positive environmental and social impacts in the first place. Aim for an offering which meets human needs and provides economic, environmental and social benefits.

Examples of Functionality

- Mobility is one of the functions provided by cars, trains etc. Instead of designing a car, focus on providing the mobility required by the end user.

- Copying documents is the functionality provided by a photocopier. Instead of designing a photocopier focus on providing the document reproduction needs of the end user.

- ❑ Once the functionality required is clear, consider all options for providing it. If possible identify a number of options for how the functionality can be met. Ask the following questions:-

  - Can it be provided through a service?
  - Can it be provided through a physical product?
  - Can it be provided through a combination of a product and service (the formal term for this is a **Product Service System (PSS)**)?



What is a Product Service System (PSS)

A PSS is a marketable combination of products and services capable of jointly fulfilling a user's need. The PSS can be provided by a single company or group of companies. It can include products (or just one) plus additional service(s).

- Significant environmental benefits as well as new business opportunities may be achieved by providing the function by a service or PSS combination. This is one of the key reasons for including this stage. This is not guaranteed but is an important strategy to include when developing a sustainable offering. The reasons for this are outlined in **Box 1**.

Box 1 Improving environmental performance by services and PSS

Providing the functionality required through a service incorporates "dematerialisation", whereby, the material and energy inputs into a product are reduced or replaced completely by an immaterial substitute. In reality, it is difficult to achieve complete dematerialisation and still achieve the required functional need. However, a combination of a product and service approach that reduces the product element is a more likely possibility. Environmental benefits can be associated with producing less product – these include reduced material and energy use, waste generation, emissions etc. The profit for the company can still be in the product and service combination. The focus is on meeting the required functionality, not on materials content.

Some examples of service elements of PSS and their features include:-

- Product extension e.g. with maintenance, repair, upgrade and end of life recovery services
  - Designing long lasting durables designed for repair, upgrade and recovery for reuse minimises resource use and waste generation while not compromising on meeting the end users needs.
  - End of life product is seen as an asset for recovery and reuse, not waste
  - Xerox provide upgrade, repair and recovery for reuse services for photocopiers (See Xerox case example in Part IV)
- Product utility services e.g. when goods are hired or leased rather than sold
  - A number of examples of this exist for cars, office equipment and carpets e.g. Interface Inc.
- Substitution e.g. when electronic services are substituted for physical processes
  - Ticket free airline check-in
- Advice and consultancy

- e.g. energy or water efficiency in equipment
- e.g. provision of advice on chemicals storage, management and end of life with chemicals.

❑ If PSS is a feasible option consider the elements it could incorporate e.g.:-

- Training
- Financing
- Service contracts for leasing, upgrade or repair
- Recovery services
- Second hand market development.

❑ The environmental and social impacts associated with services, products or PSS will be different for each option and are assessed in the Sustainability Assessment (see section 3.3.1.4) step as part of the implementation.

❑ It should be noted that social impacts may be associated with the replacement of a product by a service where this is feasible (e.g. more or less employed). For this reason both the environmental and social impacts are incorporated in the Sustainablity Assessment to ensure a TBL sustainable offering.

❑ Consideration of alternative ways to meet a functional need is important to identifying the most sustainable offering. Use an open-minded approach not fixed on a specific offering (product, service or PSS) as this is important to delivering original, out of the box solutions.

3.3.1.2 Life Cycle Stages and using Life Cycle Thinking

❑ For each of the options identified, determine the associated lifecycle stages using **Life Cycle Thinking**.



Life Cycle Thinking is about considering all lifecycle stages associated with an offering, not just its production, which has been the traditional thinking. The impacts of all life cycle stages need to be considered in order to more effectively reduce sustainability impacts.

- For a product or PSS the typical lifecycle is illustrated in **Figure 7.** The first lifecycle stage is the function required. The remaining stages include the acquisition, processing and use of raw materials, production, distribution, consumption, end of life and potential recovery options (illustrated by the dashed lines) for reuse, energy recovery, recycling, treatment and/or disposal.

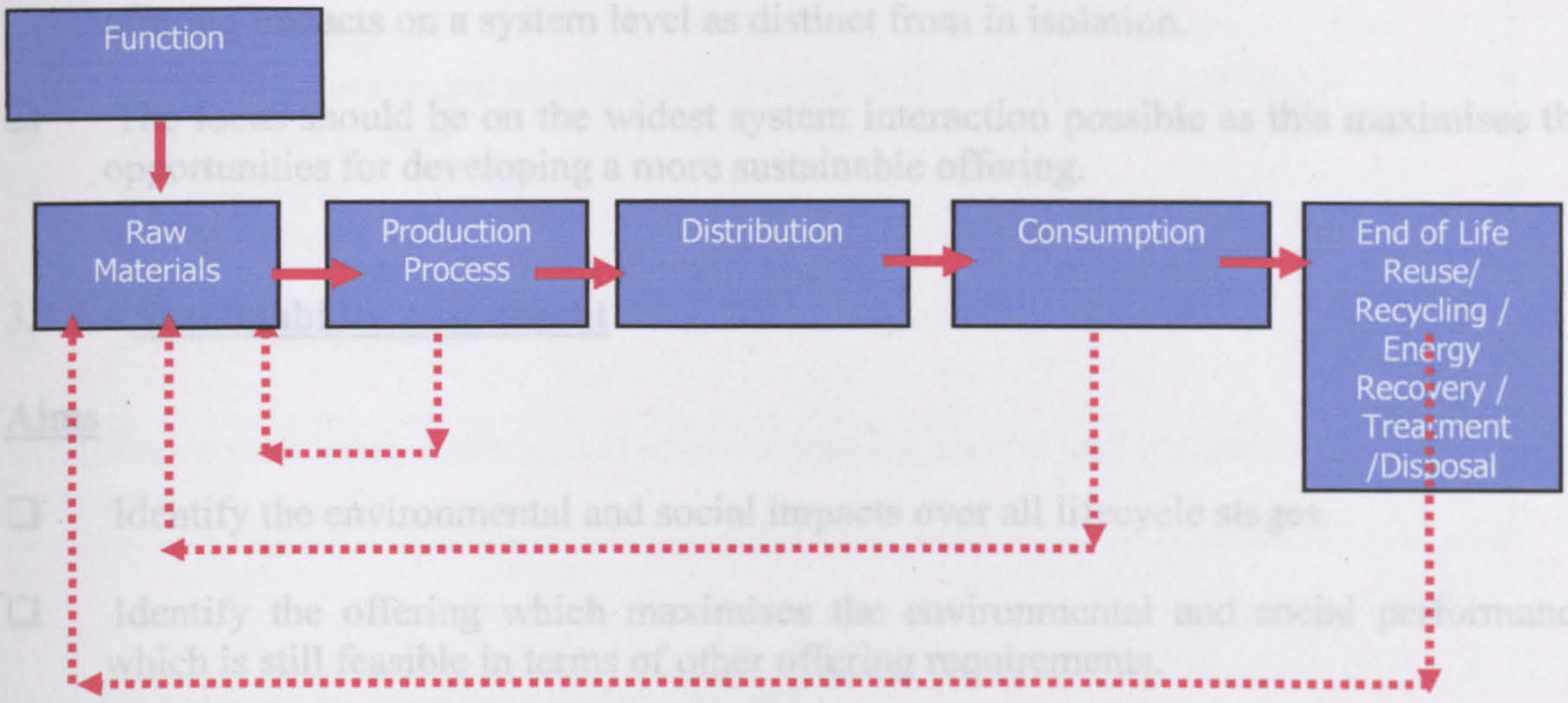
- A **cradle to cradle**, closed loop lifecycle from offering conception to end of life and beyond, incorporating recovery, reuse, recycling etc. should be aimed for as this maximizes the opportunities for environmental benefit.



- Do not consider offerings as having one finite lifetime at which disposal is the only outcome. Aim for a cyclical, continuous closed loop cradle to cradle system(s) mimicking natural processes. Design the offering with its ongoing use in mind. To maximize environmental performance, design the offering such that when it does come to its eventual end of operational life that it can be reused in line with its original use. This is called upcycling. Environmentally this is preferable to recycling or downcycling where the end of life offering or its components are recycled as a material to make something else which it was not originally designed for. Determining End of life strategies incorporates a range of issues depending on the offering. On the technology side consider the timescales associated with the following in determining the most suitable strategy:-

  - Wear out life
  - Technology cycle
  - Design cycle
  - Number of parts
  - Level of integration.

Figure 7 Product and PSS Life Cycle Stages



3.3.1.3 Consider the wider systems interactions

- In identifying the options for providing the function required, consider the wider system in which the offering (be it a product, service or PSS) is likely to interact with throughout its lifecycle stages.

- Consider the institutional, infrastructural, network and consumer interactions. Some examples to consider are below.

Examples of the interaction of the offering with wider systems

- The institutional and infrastructure related to using the product and/or service
  - ⇒ e.g. leasing instead of purchase and ownership ;
  - ⇒ e.g. the infrastructure required for cars e.g. petrol stations and roads;
- The end user behaviour e.g. consumer driving techniques affect the overall environmental impact of using a car.

- ❑ The impacts associated with these interactions will be incorporated in the Sustainability Assessment (see section 3.3.1.4) to give a true assessment of the offering impacts on a system level as distinct from in isolation.

- ❑ The focus should be on the widest system interaction possible as this maximises the opportunities for developing a more sustainable offering.

3.3.1.4 Sustainability Assessment

Aims

- ❑ Identify the environmental and social impacts over all lifecycle stages.

- ❑ Identify the offering which maximises the environmental and social performance which is still feasible in terms of other offering requirements.

Strategies to Maximise Environmental and Social Performance

- ❑ The strategies to maximise the environmental and social performance respectively are illustrated in **Boxes 2 & 3** respectively. All the strategies for maximizing environmental and social performance should be considered. There is some overlap between them. The relevance of each strategy will differ in each situation. The use of several is likely to give a more sustainable result than one or two in isolation.

Box 2 Strategies to maximise environmental performance
Providing the functionality in the most sustainable way
Incorporate the wider systems interactions
Design for extended lifetime
Design for recovery for reuse
Design for recovery for recycling, energy recovery, treatment etc.
Material and Resource Use ❑ Use of environmentally beneficial, naturally compatible, low impact materials ❑ Eliminate or reduce materials and energy usage ❑ Eliminate or reduce impacts from extraction and processing

Maximise environmental performance in:-

- ❑ Production process
  - resource usage and elimination or reduction of waste and emissions
- ❑ Distribution system
- ❑ Consumption
  - Energy etc.
- ❑ Packaging
- ❑ End of Life systems

Compliance with local, national and international legislation and voluntary initiatives

Box 3 Strategies to maximise social performance

Incorporate employee conditions of work in the company and in sub contract organisations along the supply chain (in local and global locations)

- ❑ e.g. equality, equity, child labour, forced labour, health and safety

Incorporate impacts of company activities on local and global communities

- ❑ Investment and development
- ❑ Local residents

Incorporate the political and social implications of the location and methods of raw material extraction and processes

Opportunities to respect and enhance regional, cultural and material diversity

Stakeholder engagement in terms of transparency, communication and accountability

Compliance with local, national and international legislation and voluntary initiatives

The SPSD Sustainability Assessment Checklist (see section 3.4) incorporates these strategies and provides a checklist for incorporating them over all lifecycle stages. This is a generic checklist of typical functionality, environmental, social and other offering criteria which can be considered per lifecycle stage in the SPSD process. Examples of typical assessment criteria for determining environmental and social impact are included.

- ❑ The SPSD Sustainability Assessment Checklist should be customised as necessary and used as a guide for what to consider in the assessment. All criteria relating to the development of the offering whether customer requirements, quality, economic,

functionality, technical feasibility, environmental and social should be incorporated together in the one offering development checklist for ease of use. This can be supported by a variety of tools as relevant. Examples of typical issues related to traditional product criteria e.g. market, technical, legal and quality are also included in the checklist. The checklist is a guide to the TBL issues to be considered in the development of a sustainable product and/or service. This checklist contains generic examples that should be suitably customised in each situation e.g. dependent on the sector, product and/or service and companies involved. Examples of additions to the checklist are technical specifications, WEEE and RoHS compliance obligations (see Part IV on CD ROM) (for electronics goods, as relevant), specifications for labels (see Part IV on CD ROM) e.g. ***Energy Star*** (for electronics goods).

- ❑ If required, additional support tools to the SPSD Sustainability Assessment checklist should be used. To determine whether and which tools to use consider parameters such as sector; type and complexity of the offering involved; existing information on sustainability impacts and existing product development process used. See Part IV of the guide (on CD ROM) for information on additional supporting tools.

- ❑ Life Cycle Thinking is applied to both environmental and social impacts and is used to identify and assess the sustainability impacts associated with each lifecycle stage. This is not Life Cycle Assessment (LCA) as defined in ***ISO140040*** (ISO, 1998) but a simplified, more qualitative, flexible assessment. Life Cycle Thinking provides a qualified assessment of the environmental and social impacts. This may be sufficient for the assessment. As required, this can also be supported by suitable quantitative tools e.g. LCA, abridged LCA and others where more detailed information is required. See Part IV (ON CD ROM) for guidance on additional support tools (see Part IV on CD ROM).

Initial Sustainability Assessment

- ❑ Once the lifecycle stages for the options for meeting the required functionality are defined, an initial assessment should be conducted to determine the environmental and social impacts associated with each lifecycle stage and identify the opportunities for maximising the environmental and social impacts.

- ❑ Assess each potential option for meeting the functionality overall all lifecycle stages. The aim is to limit this assessment to provision of the functionality while maximising environmental and social performance. Other traditional criteria should be excluded from this initial assessment, so as not to limit creativity and identification of all options for maximising environmental and social benefit. Once these are identified, the traditional criteria can be added to the assessment. Adding these criteria should narrow down the options for the offering that feasibly meets the criteria required.

- ❑ Using the SPSD Sustainability Assessment Checklist, identify the opportunities for maximising the environmental and social benefits. The checklist questions are designed to include the typical strategies for achieving this. For example consider

- choosing raw materials which can be reused for their original purpose when the end offering has reached its eventual end of life. Consider the opportunities for reusing production waste as a raw material. Consider the use of reusable returnable packaging generated at the consumption lifecycle stage. This aims for a closed loop cradle to cradle lifecycle as illustrated by the dashed lines in **Figure 7**.

Full Sustainability Assessment

- The feasibility of the options that maximise environmental and social performance should be assessed in terms of the additional offering criteria e.g. (not in order of priority):-
  - ⇒ customer requirements;
  - ⇒ market demand;
  - ⇒ technical feasibility;
  - ⇒ quality;
  - ⇒ compliance with relevant policy/regulatory requirements (environmental, health & safety, industry specific etc…);
  - ⇒ compliance with relevant industry/technical specifications e.g. CE marking;
  - ⇒ third party product validation options i.e. Environmental Product Declarations (e.g. eco labels);
  - ⇒ economic issues e.g. cost.

- The design that best meets all the criteria can be considered the most feasible sustainable option.

- Each company is likely to have different priority weightings per offering criteria. Prioritising the environmental and social will maximize their associated performance in the offering.

- In conducting the Sustainability Assessment, include the impacts associated with the wider systems in which the offering (be it a product, service or PSS) interacts.

- The assessment should incorporate all lifecycle stages of the offering

- During the assessment of the environmental and social impacts identify any communication or marketing opportunities that would maximize environmental and social benefits. For example, instructions for the end user to ensure efficient energy use to facilitate end of life reuse or recycle options. Potential opportunities for branding or marketing the sustainability benefits e.g. through environmental or social labeling schemes (see Part IV on CD ROM) should be identified and their feasibility for these purposes investigated further. Information for communication and marketing opportunities can be developed further for use at the Offering Launch and Marketing (see section 3.3.5) stages of the offering development.

- On completion of the full sustainability assessment, the sustainability impacts associated with each offering option should have been identified and evaluated. The offering(s) that best meets the product and/or service criteria (environmental, social, and more traditional criteria) can then move onto the detailed design stage. As required, decision support tools (see Part IV on CD ROM) may be used to facilitate the final decision making process. The final offering option(s) can then be consolidated into specifications as per traditional product development practice.

3.3.1.5 Supply Chain Dynamics and Supply Chain Management

- Once it has been determined what the offering to be developed is (i.e. a product, service or combination) and the lifecycle stages are clear, the associated supply and value chains should be finalised. This is typically not clear until the Offering Development phase (see section 3.3) is well advanced.

- The role of each supply chain organisation and their influence and control over lifecycle stages with key sustainability impacts should be assessed. This will determine their role in SPSD implementation.. Typically, the SPSD implementation occurs at Original Equipment Manufacturer (OEM) level and aspects of it are spread through the supply chain mainly through changes in the product and/or service specification.

- Full SPSD implementation is typically not required by all supply chain companies, just the one(s) with control over the offering design and main life cycle phases with key sustainability issues. However, the integration and co-ordination of all relevant supply chain companies into the process (even if solely on an information supply basis) is crucial.

- A key element of SPSD is that it focuses on the supply chain for the product and/or service rather than solely at an individual company level.

- The entire supply chain and supply chain dynamics (SCD) should be assessed to determine the most effective target organisation(s) in the chain for SPSD (i.e. company(ies) with control of the product and/or service conception, design and development lifecycle stages) and for implementation up and down the supply chain using Supply Chain Management (SCM).

3.3.2 Detailed Design

- Once the offering (product, service and/or PSS) to be developed is identified in the Concept Development phase, detailed design and testing/prototype development commences. This is in line with traditional product development processes. Based on the detailed design, prototype development and testing phases, the offering specification can be finalised prior to production or introduction into service. Further concept development activities may be required if detailed design or testing flag problems (either with traditional or environmental and social criteria) with the offering.

- The ongoing information supports to include the following should continue to be used throughout the Detailed Design, Testing/Prototype stages as relevant:-
  - Sustainable Products and/or Services Database of information resources (see Part IV on CD ROM);
  - Legal compliance obligations (see Part IV on CD ROM);
  - Industry schemes, voluntary standards and labels (see Part IV on CD ROM);
  - Relevant information from supply chain companies e.g. data on raw materials, components, assemblies etc.;
  - Relevant data on alternatives (e.g. materials, energy sources) from existing data sources e.g. suppliers, databases etc.

- Additional support tools (see Part IV on CD ROM) may be incorporated as required.

3.3.3 Testing/Prototype

- The development of prototypes and testing against the required offering specification in terms of environmental, social and all other criteria is conducted in this stage.

- The prototype development and testing can encompass a range of offering elements (e.g. components) as well as the total offering and the overall offering process. All aspects of the product, service or PSS under development should be tested. Testing should encompass all offering specification requirements to incorporate the following.
  - Functionality
  - Quality
  - Technical (e.g. material properties, durability, lifetime, manufacturability, disassembly, reuse)
  - compliance with relevant policy/regulatory requirements (environmental, health & safety, industry specific etc.);
  - compliance with relevant industry/technical specifications e.g. CE marking;
  - third party product validation options i.e. Environmental Product Declarations (e.g. eco labels);

- Environmental
- Social
- Economic.

Testing of service elements can be against the expected outcomes defined in the service specification.

- ❑ Based on the testing results, changes required to the offering design should be identified, implemented (by revisiting earlier offering development stages as required) and the offering specification finalised.

3.3.4 Production

- ❑ Based on the finalised offering specification, production can commence. For a new offering, the infrastructure relevant to provision of the product, service or PSS will need to be set up as required. Once initial production has commenced, the sustainability impacts should be reassessed against the original sustainability impacts to determine if any additional unforeseen impacts to the specification are arising from mainstream production. Rework and revisiting of earlier steps in the development process may be required if this is the case.

- ❑ Where a PSS offering is being produced, production of the product as well as set up for the delivery of service elements will take place in this phase. If service elements have not been incorporated in previous offerings, increased personnel and time resources may be required during production compared to previous developments.

3.3.5 Offering Launch and Marketing

- ❑ Based on the opportunities for communication and marketing of the sustainability impacts identified in the Concept Development phase (see section 3.3.1), finalise the requirements for communication and marketing of the offering.

- ❑ As relevant, information to facilitate maximising the environmental and social benefits of the offering during use for the target customers or other stakeholders (e.g. end of life recovery operators) should be determined and communicated. This information will have been previously identified in the sustainability assessment. Based on this, an appropriate communication strategy should be developed and implemented. Examples could include:-

  - customer information advising on best use (e.g. energy efficiency),
  - leasing arrangements,
  - upgrade or end of life recovery arrangements.

- ❑ On the marketing front, the marketing benefits of the sustainability aspects of the offering where relevant should be determined. Again, based on the sustainability

assessment, marketing information, as relevant, will have been identified. Examples include third party declarations e.g. *Energy Star* or the *EU Eco label* that demonstrate environmental benefits or *Fair Trade* that focus on social issues to a predefined specification. Where suitable, accreditation to these schemes may be obtained and used for the marketing of the offering's sustainability benefits. See Part IV (on CD ROM) for more information on environmental and social focused labeling schemes.

- ❑ All environmental and social information to be used in a marketing context should be backed up with the appropriate proof that these criteria are met in reality. The specifications defined in relevant third party declarations or standards e.g. ISO14020[3] series are useful for clearly specifying this information.

3.3.6 Offering Review

- ❑ The offering review stage should incorporate the entire development team in order to provide feedback on issues such as:-
  - the development process,
  - the sustainability and other business impacts of the final offering,
  - evaluation of whether the final offering met the full specification requirements;
  - feedback from stakeholders in particular customers;
  - experiences learnt which can be used to improve future offerings and/or the development process.

- ❑ The feedback from the Offering Review stage should be incorporated into revisions of the company's offering development process to facilitate future offering development.

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[3] ISO14020 Environmental labels and declarations – General principles
ISO14021 Environmental labels and declarations – Self declared environmental claims (Type 11 Environmental Labelling)
ISO14024 Environmental labels and declarations – Type 1 environmental labelling – Principles and procedures
ISO14025 Environmental labels and declarations – Type 111 environmental declarations

3.4 SPSD SUSTAINABILITY ASSESSMENT CHECKLIST

Guidance on the issues to consider in the sustainability assessment are in the following checklist:-

- Functionality
- Environment
- Social
- Economic
- Technical, Quality, Legal/Industry and Market

SPSD Criteria	Life Cycle	Issues to Consider (as relevant)
Functionality	**Function**	**Strategy: Determining the most sustainable way to provide the function required**
		What is the human need/functionality required?
		How can this be achieved?
		Do you need a product?
		Could this be achieved by a service?
		Options for PSS?
		What are the wider systems in which the options for product, service or PSS will operate?
		Is packaging required?
		Strategy: Extend Life Time
		Design for durability
		Design for repair and maintenance
		Modular design for maximising upgradeability
		Timeless design compared to short term trends
		Possibilities for recovery for reuse, energy recovery, recycling, treatment and/or disposal
		Possibilities for leasing products on a continuous service contract rather than once off sales

Environmental Impact	**Raw Materials**	**Strategy: Use of environmentally beneficial or low impact materials**
		Type of raw materials
		Eliminate or reduce non-renewables usage (Fossil fuels, metals, timber, plastics, paper)
		Substitute scarce minerals for those that are abundant
		Consider long term resource availability
		Substitution of hazardous raw materials for non/less hazardous ones that can be assimilated by natural systems
		Avoid ozone depleting substances and high greenhouse gas emitting substances
		Source renewable resources from sustainably managed restorative ecosystems
		Choose recycled raw materials over virgin materials
		Choose raw materials to facilitate extending product life
		Strategy: Elimination or reduction of materials and energy usage
		Reduce the volume of materials used Dematerialisation
		Reduce energy usage
		Limit and reduce use of natural resources
		Reduce impacts from extraction, process & transport of raw materials
		Preference for local raw materials
		Design offering to have an extended operating life
		Choose raw materials to facilitate end of life recovery for (in order of priority) reuse, recovery for energy recovery, recycling, treatment and/or disposal
		Minimise the diversity of materials used to facilitate reuse, recycling, energy recovery of final disposal
		Avoid the use of composites
		Reduce the number of components and assemblies
		Reduce land use particularly regarding land cosuming materials and infrastructure associated with the offering
		Use in mould material identification labelling

	Production	**Strategy: Maximise environmental performance in production**
		Use a Cleaner Production approach/technologies
		Eliminate/reduce emissions to air
		Eliminate/reduce effluents
		Eliminate/reduce waste
		Eliminate/reduce packaging
		Opportunities for reuse of production waste as raw material on site
		Opportunities for reuse, energy recovery or recycling of production waste off site
		Eliminate/reduce energy usage
		Use resource as efficiency as possible e.g. energy and water usage, to include recovery and reuse opportunities
	Distribution	**Strategy: Maximise environmental performance in distribution**
		Is storage necessary?
		Eliminate/reduce materials and energy use in storage.
		Is transport necessary?
		Volume & nature of transport
		Eliminate/reduce transport distances
		Minimise weight of product and packaging to save space and energy in transport
		Type of fuel usage
		Eliminate/reduce emissions to air
		Eliminate/reduce waste
	Consumption	**Strategy: Maximise environmental performance in consumption**
		Eliminate/reduce waste from product
		Eliminate/reduce waste from packaging
		Eliminate/reduce energy consumption in standby and operational modes
		Use customer communication mechanisms to maximise environmental performance during use e.g. energy use, take back arrangements for consumables, packaging and product
		Eliminate/reduce material consumption e.g. consumables required during operation
	End of Life	**Strategy: Maximise environmental performance at end of life**
		Extend offering life through repair, upgrade and maintenance

		Recovery for reuse of complete product (e.g. secondary market)
		Recovery for disassembly & recovery of components for reuse and remanufacturing
		Recovery for disassembly & recovery of components for recycling, energy recovery or treatment/disposal
		Guarantee and convenience of take back for recovery for the end user?
		Reduce material and energy use in reuse, recycling, treatment/disposal options
		Eliminate/reduce material, energy use, waste & emissions from recovery, disassembly, reuse, recycling, treatment/disposal options
		Take back of packaging for reuse or recycling?
		In final disposal closing biological cycles e.g. biodegradable
Social Impacts	**Raw Materials**	Are the raw materials extracted/processed in the developing world?
		Ownerships rights
		Are the trading arrangements fair and equitable?
		Are their political and social implications from raw material extraction and processing?
	Production & Distribution	Employee conditions of work at company and work in sub contract companies
		Respect human rights , values and their different cultural contexts throughout all operations and global locations
		Implement diversity policies to eliminate discrimination
		Provision of safe, secure working conditions
		Adopt fair labour practices to include equality and exclude child labour or forced labour
		Provide fair, reasonable remuneration for employees
		Ensure health and safety to include physical and mental well being
		Provide access to training, and create an enabling environment for learning and development
		Support health promotion and education
		Impact on local community e.g. local

		residents, political or social implications
		Investment in development of local community e.g. use of local service providers and supplies
		Investment in local community e.g. financial supports (charities, schools) and sharing expertise
	Consumption	Eliminate/reduce adverse health/safety impacts for the local community
		Eliminate/reduce adverse health/safety impacts for the global community
	End of Life	Eliminate/reduce adverse health/safety impacts for the local community
		Eliminate/reduce adverse health/safety impacts for the global community
	All phases	Compliance with the company's ethical code of conduct
		Consistency between company policies, communications, marketing and actual activities and offerings
		Communication with local and global community in terms of transparency and accountability e.g. reporting mechanisms
Economic Aspects	**All phases**	Internalise environmental and social externality costs (e.g. end of life recovery, reuse/treatment/disposal) by assigning an economic value to them. Incorporate these costs or benefits in the overall economic assessment of the offering
		Incorporate the economic impacts on risk and corporate governance of adverse environmental and social performance
		Incorporate the wider economic impacts of the companies activities and offering on society e.g. investment in local community
		Incorporate intangible assets e.g. reputation and brand
		Is the offering cost effective?
		Does the offering cost the same/less than competing versions?
		Is their potential for a new source of profit from service or PSS combinations?

Technical specification	**All phases**	Does the product &/or service provide the required functionality?
		Is it technically feasible to manufacture/provide?
Quality	**All phases**	Does product &/or service meet defined quality specifications?
		Is it of suitable integrity, durability?
Legal/industry requirements	**All phases**	Does product and/or service meet required legal/industry standards? e.g. • Environmental • Health & Safety • Product/Service standards • CE Marking • Standards/legislation in export markets
		Consider whether existing labelling schemes are applicable for the product and/or service
Market requirements	**All phases**	Does it meet customer requirements?
		Are there competing offerings?
		Is it a domestic/export market?
		Does sustainability contribute to the marketing/brand? How?
		Information/Communication for marketing campaign

SECTION V DISCUSSION AND CONCLUSIONS

The evaluation of the research findings in terms of the original research aim, objectives, questions and method used are described in **Chapter 11.** The final conclusions and recommendations are discussed in **Chapter 12.**

> *"Less bad is not good enough".*
> (European Roundtable on Sustainable Consumption and Production, 2004)

CHAPTER 11 DISCUSSION

11.1 INTRODUCTION

The research enabled the "grand tour" question to be answered which reflects the original research aim. These are restated below:-

GRAND TOUR QUESTION

How can an approach for developing sustainable products and/or services be implemented effectively in industry to result in the development of products and /or services that prevent, or minimise adverse sustainability impacts as well as incorporating industry requirements?

RESEARCH AIM

- **Facilitate the development of sustainable offerings (e.g. products and/or services) by industry, through a Triple Bottom Line focused implementation approach for developing sustainable products and/or services which eliminate, or minimise adverse sustainability impacts, as well as incorporating industry requirements.**

Specific research objectives were defined in order to achieve this aim. To answer the grand tour research question and meet the aim and objectives, a range of research questions were defined as follows:-

RESEARCH QUESTIONS

1. *What existing approaches relevant to developing sustainable products and/or services are available to industry?*
2. *Is there a need for a support for developing sustainable products and/or services?*
3. *What are the drivers for manufacturing industry to produce more sustainable products and/or services?*
4. *How does manufacturing industry implement approaches relevant to developing sustainable products and/or services?*
5. *What are the requirements of manufacturing industry to produce more sustainable products and/or services?*
6. *What is effective SPSD implementation and what are the factors relevant to effective SPSD implementation?*
7. *What are the criteria for effective SPSD implementation approaches to incorporate industry requirements and result in the production of products and/or services with reduced sustainability impacts?*
8. *To what extent do existing approaches meet the criteria for effective SPSD implementation?*
9. *Does the implementation using the SPSD approach result in the development of offerings (products, services or PSS) with TBL sustainability benefits (environmental, social and economic)?*

   Note: offerings with TBL sustainability benefits were defined as preventing, where possible, or minimising adverse sustainability impacts?
10. *What are the experiences and views of implementing companies as to the effectiveness and practical use of the SPSD approach as a support for the development of sustainable products and/or services?*

The phases of the research were conducted to investigate these questions and ultimately achieve the aim and objectives. A research method was developed to enable a rigorous and reliable investigation to answer the questions (see **Chapter 2**). Due to the diverse nature of the research questions, multiple research strategies were used to include semi structured interviews, questionnaires, literature review, case study research and participant observation (as the researcher had unique access to real life industry and practitioner information and experiences relevant to the research) (Creswell, 2002; Yin, 2003). Multiple data sources including literature, companies, practitioners, academics and policy makers relevant to developing sustainable products and/or services were used[1]. Quality controls were incorporated in the research method as discussed in **Chapter 2, 2.3**.

This chapter discusses the research findings and analyses how they relate to the research aim. Also, a critique of the research method used and effectiveness of the quality controls incorporated are in section **11.3.** Recommendations for future research are in section **11.4.**

11.2 RESEARCH FINDINGS

11.2.1 Background, existing approaches, drivers and activities for developing sustainable offerings

Phase 1 of the research investigated research questions 1-5. This is described in **Sections I** and **II, Chapters 3 – 5**. The review of the existing problem, drivers, approaches and how they are currently used in industry clarified the background and current status regarding developing more sustainable products and/or services.

A need for a Triple Bottom Line (TBL) focused approach for developing more sustainable offerings was identified. Firstly, this was based on the need to improve the environmental and social performance of offerings, as one part of combating the adverse environmental and social impacts associated with production and consumption (EC, 1998; EC, 2000; EC, 2001; UNEP I& E et al, 1997a; UNEP WG SPD, 2000; UNDESA, 2002; EC, 2003;

[1] See **Appendix 2** for a description of the data sources.

DEFRA, 2003; Davidsson, 2002; WWI, 2004; Tischner and Charter, 2001; Klein, 2001; Elkington, 1997). Secondly, increasing industry drivers for improving sustainability performance in general, as well as a focus on improving the environmental performance of products highlighted a growing requirement for an approach to support developing more sustainable offerings (UNDESA, 2003; EC, 2002a). However, no direct legal driver for a TBL focused approach exists at present as these focus on reducing specific environmental impacts of certain types of products (e.g. packaging, vehicles and electronics) (EC, 1994; EC, 2000a; EC, 2003a; EC, 2003b) with few drivers for improving the social performance of products. Market pressure in the form of voluntary initiatives e.g. *Fair Trade* or protecting corporate reputation and branding are the main social improvement drivers. Sustainability focused voluntary initiatives e.g. Corporate Social Responsibility and the recently emerging Sustainability Management Systems illustrate a shift to focus on the social impacts of industry activities, products and services as well as the environmental and economic issues. From a policy context, Sustainable Consumption and Production (SCP) shifts the focus towards improving TBL sustainability performance of products and services rather than just environmental performance (de Leeuw, 2004; Wijkmann, 2004). In light of these developments, the need for a TBL focused approach to improve the sustainability performance of offerings was identified.

The current lack of direct drivers for producing more sustainable offerings from industry was seen as a significant issue in terms of motivating stakeholders towards SCP. It is also a significant issue impacting the use of industry approaches which support this e.g. the new SPSD approach. These issues are discussed in section **11.2.4**.

The review of the existing approaches relevant to developing sustainable products and services[2] found that no existing mainstream TBL focused approach incorporating environmental and social criteria to support the process of developing sustainable products and/or services was currently available to industry. This clarified that there was not an existing approach meeting the needs identified and substantiated the requirement for a new

[2] See **Chapter 4**.

approach. However, the review identified existing concepts, strategies, methods and tools relevant to aspects of developing sustainable offerings to build upon to include:-

- a wide range of Environmental Product Development (EPD) approaches e.g. ecodesign and eco (re)design (Simon et al, 1998; Croner, 2000; Charter ,1999; Byggeth et al, 2000 and Byggeth & Broman, 2000);
- a smaller number of Sustainable Product Development (SPD) concepts and approaches starting to develop (Mont, 1999; Byggeth and Broman, 2000; Charter and Tischner, 2001; Holmberg, 2000; ADL, 2001; Simonsson and Barthel, 2002);
- approaches improving the TBL sustainability performance of industry in general;
- systems focused approaches e.g. eco-efficient services and Product Service Systems (PSS).

In terms of industry activities, outside of those activities responding to legal and market drivers for reducing specific environmental impacts associated with certain sectors and products (e.g. electronics, automotive and packaging), awareness and a requirement to develop more sustainable products and/or services is low. Where activities exist, they mainly focus on the ecodesign (and specifically eco(re)design of products), with little TBL focused activities (integrating of social, environmental and economic issues) for developing sustainable product and/or services (Simonsson and Barthel, 2002, ADL, 2001, Croner, 2001;Mont, 1999; Holmberg et al, 2000; Tischner et al, 2000). A small number of innovative companies are illustrating elements of a TBL focused approach to activities in general and in their product development. A lack of clarity regarding how to integrate social issues, in general, as well as in the development of sustainable offerings was evident (Simonsson and Barthel, 2002; ADL, 2001; Charter, 2001; Charter and Tischner, 2001).

11.2.2 SPSD Criteria and Assessment

Phase 2 of the research was to answer questions 5-7. The investigation and results are documented in **Section III Development of SPSD Criteria and Assessment, Chapters 6-7.**

In investigating what was needed in order to incorporate industry requirements and result in the development of products and/or services with reduced sustainability impacts, the criteria for effective SPSD implementation were developed. This was based on an analysis of the following, as relevant to developing sustainable products and/or services and using multiple data sources:-

- ❑ industry drivers and requirements;
- ❑ current industry activities;
- ❑ existing approaches and how they are implemented;
- ❑ factors necessary for effective SPSD implementation.

Based on the analysis, the internal and external criteria in **Box 11.1** and **11.2** were defined[3].

Box 11.1 Internal Criteria

1. Shifting the mindset of manufacturers from the provision of products to the provision of functions to meet human need;
2. Moving from a focus on individual products to the systems in which products and services operate;
3. Incorporation of all product and service lifecycle stages;
4. Moving from a "greening up" environmental focus to a TBL sustainability focus;
5. Incorporating a strategy level commitment to developing sustainable products and/or services and integrating SPSD with all business systems;
6. Integrating TBL criteria with other traditional product and/or service criteria;
7. A simple, flexible, non resource intensive, customised approach in line with business realities;
8. Use of business language suited to the company and industry sector culture;
9. Increased focus on supply and value chains;

[3] See **Chapter 6** for a discussion of these criteria.

10. Targeting SPSD implementation at appropriate companies based on the supply chain dynamics and their control of the product and/or service conception, design and development lifecycle stages
11. Integration and co-ordination of supply chain organisations;
12. Availability of resources and effective communication;
13. Effective organisation and management internally and across the supply chain.

Box 11.2 External Criteria

1. Strong legal and market drivers;
2. Provision of a strong, clear business case for SPSD;
3. Changing operating models for business and consumers.

Internal criteria are relevant to an SPSD implementation approach. External criteria are outside the scope of this implementation process and relate to the larger systems, infrastructure, policies and drivers to promote the development of sustainable offerings in general and involve a wider range of stakeholders, not just industry. As this research was focusing specifically on identifying the criteria for SPSD implementation approaches for industry, the thirteen internal criteria were incorporated into an SPSD implementation approach[4]. The intention was that in this approach these criteria would result in effective SPSD implementation i.e. incorporating industry requirements and resulting in the production of products and/or services with reduced sustainability impacts. The external criterion 2 (Provision of a strong, clear business case for SPSD) was incorporated in the context of information provision of the business case for SPSD. The external criteria 1 (strong legal and market drivers) and 3 (changing operating models for business and consumers) were outside of the scope of an implementation support and hence were not incorporated other than in an information provision context in the business case.

Both the internal and external criteria highlighted a number of existing barriers to developing sustainable offerings (Maxwell et al, 2003a). Incorporating those that were relevant to an implementation approach for developing sustainable offerings was seen as

[4] The criteria for effective SPSD implementation relevant to an implementation approach are listed in **Chapter 6**.

important to overcoming these barriers. The external criteria are an important part of the wider system elements necessary to drive industry and other stakeholders to consider developing sustainable offerings and create the necessary business environment. These are discussed in section **11.2.4.2**.

In order to answer research question 8, existing implementation methods relevant to aspects of developing sustainable products and/or services identified from the review of existing approaches were assessed against the criteria to determine the extent to which they met these, how and what new aspects would be required for a new SPSD approach. The assessment showed that none of the implementation methods incorporated all the assessment criteria. In particular, none of the methods met the following two criteria:-

- ❑ Shifting the focus from a "greening up" environmental focus to a TBL sustainability focus and integrating TBL sustainability criteria with other traditional product and/or service criteria;
- ❑ Considering the Supply Chain Dynamics (SCD) of the product and/or service supply chain to determine the most effective target company (ies) for SPSD implementation (i.e. company (ies) with control of the product and/or service conception, design and development lifecycle stages) and for implementation up and down the supply chain.

The remaining criteria were evident in the methods assessed to varying extents[5]. Those elements of the existing methods incorporating the criteria plus all approaches reviewed were built upon in the new SPSD approach.

[5] See **Chapter 7** for details on the extent and how for each criteria.

11.2.3 New SPSD Approach

Phased 3 of the research developed and evaluated the new draft SPSD approach based on the SPSD implementation criteria and the results of the assessment. This is described in **Section IV, Chapters 8-10.** In line with the research aim, the SPSD approach describes an implementation process for industry incorporating the SPSD implementation criteria to support the development of sustainable offerings. A summary of the new SPSD term and implementation approach developed is in **Box 11.3.**

Box 11.3 New SPSD Approach

SPSD is the process of making offerings – be it a product, service or PSS (i.e. a product and/or service)- in a more sustainable way in terms of environmental protection, social equity and economic prosperity throughout their entire lifecycle (cradle to cradle) while still meeting other key requirements (Maxwell and van der Vorst, 2003). The SPSD approach provides a framework process for implementing SPSD throughout the complete lifecycle of an offering and the associated supply chain. The stages are:-

- Planning
  - Organisation, Management and Communication
  - Provision of Introductory and Ongoing Information
  - Strategic Commitment and Integration into Existing Business Systems
- Offering Development
  - Concept Development
  - Detailed Design
  - Testing/Prototype
  - Offering Launch and Marketing
  - Offering Review.

It aims to identify, assess and implement the options for integrating sustainability in product and/or service development. The SPSD approach integrates with existing Sustainable Production approaches for industry. It provides a flexible framework for implementing SPSD in the form of suggested actions supported by information and examples to inform and inspire the user and a flexible toolbox.

SPSD builds on a wide range of existing concepts and approaches (to include sustainability, systems thinking, EPD and SPD) and evolves them further to meet the requirements of developing sustainable offerings based on the criteria for effective SPSD implementation.

The advancements SPSD incorporates and their role in supporting the development of sustainable offerings are as follows:-

- Overall, SPSD shifts the focus to developing "sustainable offerings" in a TBL context instead of "greener products". This incorporates all TBL elements (environment, social and economic) and integrates them with other traditional product and/or service criteria e.g. quality and technical feasibility, in the development of sustainable offerings. This is a rethink of existing approaches largely designed with only environment in mind to incorporate the increasing shift towards TBL sustainability.

- On the social side of improving the sustainability performance of offerings, a need to move beyond reducing the environmental burden to incorporating environmental and social issues in a TBL context was identified (European Foundation, 1997; Brezet et al, 2001; Charter and Tischner, 2001; Dobes and Majer, 2002). As the assessment of industry approaches determined that in the main, existing approaches focus on the environmental dimension of sustainability alone and do not incorporate all TBL (social, environmental and economic) issues (Simonsson and Barthel, 2002; Simonsson, 2002; European Foundation, 1997; Byggeth & Broman, 2000; Charter and Tischner, 2001), shifting to a TBL sustainability focus incorporating environmental and social issues in offering development was an important new aspect to incorporate in SPSD.

- Focusing on the environmental part of improving the sustainability performance of offerings, SPSD incorporates elements identified as necessary for achieving more significant environmental improvements. These include consideration of functional and systems innovations as distinct from eco-efficiency improvements alone (Brezet et al, 1996; ECOLIFE, 2002) and incorporation of all lifecycle phases using a cradle to cradle approach (Hanssen, 1999; Braungart, 2002). The incremental eco-efficiency improvements resulting from the mainly eco(re)design activities seen in the majority of industrial activity in this area to date are not seen as sufficient to resolve the associated environmental problems (Roome, 2003 ;Brezet et al, 2001, van Weenan, 1997). While

providing clear incremental environmental (and economic) benefits, this approach can result in "greening up" inherently unsustainable products making them "less bad". In many cases, the existence of the product itself is not environmentally suitable and just reducing specific environmental impacts associated with specific lifecycle stages e.g. manufacture, disposal and end of life can be only scratching the surface of the problem i.e. treating symptoms, not solving the problem. Rebound effects can also occur where increased consumption of the greened products outstrips the environmental gains anyway (DEFRA, 2003). This approach is increasingly being seen as inadequate in terms of achieving long term environmental, let alone TBL sustainability (Hanssen, 1999; Hawkens et al, 1999; McDonough and Braungart, 2002; European Foundation, 1997; van Weenan, 1997; Brezet et al , 2001, Roome, 2002; Hart and Milstein, 1999; Simon and Sweatman, 1997; Frei, 1998; Byggeth et al, 2000). The majority of existing approaches focus on optimising the environmental performance of products, and in a few cases product and service systems, over a range of lifecycle stages, in particular with respect to dematerialisation, de – energisation and de-toxification (Brezet et al, 2001). Few approaches aimed at maximizing environmental performance, let alone TBL sustainability, were identified.

Issues to be considered to achieve the functional innovations required include focusing on the provision of functions to meet human needs (as distinct from products) and system based solutions. The concept of selling functions, as distinct from products, and providing functions to meet human needs by not just products, but alternatives, such as services or some combination (a PSS) are increasingly promoted as important to achieving environmental improvements (Stahel, 1997; Behrendt et al; Mont, 1999, Reiskin et al, 2000; Braungart, 2002; Brezet and van Hemel, 1997, van Weenan,1997; Hawkens et al; White et al, 1999; Engelhardt and Hammerl, 2002; Brezet et al, 2001; van Hoed, 1997; Foxon et al, 2003; Tukker, 2004). In terms of systems, instead of focusing on improving the environmental performance of individual products, focusing on improving the performance of the families of products (van Weenan, 1997) and the entire systems they interact in is advocated (van den Hoed, 1997; Mont, 2002; Brezet et al, 2001; Hanssen, 1999; European Foundation, 1997). The delivery of system focused

offerings incorporating a product, service or PSS and the infrastructural, consumer, institutional, network and user behaviour context within which it operates is seen as necessary for environmental improvements (Mont, 2002; Brezet et al, 2001). It is recognised that there are uncertainties in terms of proven sustainability benefits and the ability of manufacturers and consumers to shift towards systems innovations e.g. PSS (Mont, 2002). Research indicates that significant environmental improvements are possible by the provision of functions through services and PSS, as distinct from products alone (Goedkoop et al, 1999; Mont, 1999; Meijkamp, 2000; Brezet et al, 2001; White et al, 1999; Behrendt, 2003; EC, 2003c; Reiskin et al, 2000), but few practical success stories are currently available (Mont, 2002). Rebound effects have also been associated with this approach (Hopkinson and James, 2000) and potentially negative social impacts. Due to the potential for significant environmental benefit, the functional and systems criteria were incorporated in the SPSD approach. As such, starting offering development with a concept development phase which considered the function required, human need to be met, the requirement for it in the first place, the wider systems it interacted with and the options for its provision (services, products or PSS) all aiming at maximising environmental and social performance, was incorporated in SPSD as one of the strategies to be considered for developing sustainable offerings. An open mindset not focused on any one method of function provision (services, products or PSS) and assessment of both positive and negative environmental and social impacts was also incorporated. SPSD is not necessarily about providing every function through a PSS. It is about considering the options and using this as one strategy within functional and systems level thinking to identify the most sustainable option which may not have been considered if the starting point was a product. In some cases this may be a PSS, in others it may not.

To maximise environmental performance, consideration of all lifecycle stages and aiming for a closed loop, cradle to cradle approach (Hanssen, 1999; Braungart, 2002) was identified as more effective than targeting isolated lifecycle stages and their environmental impacts e.g. raw materials or end of life as in the case in most compliance driven EPD approaches in industry (European Foundation, 1997;

McAloone, 2000; EC, 2003; Fava and Saur, 2002; UNEP/SETAC, 2002). Also, to explicitly incorporate consideration of the functional innovations, a new lifecycle stage "function" was added as the first lifecycle stage in SPSD. The SPSD concept development phase focuses mainly on this lifecycle stage and determining the most sustainable way to provide the function required.

- SPSD takes into account the fact that in product and/or service development there are a range of organisations operating in supply chains with different roles, and abilities to control key design issues relevant to sustainability. Because of this and the requirement to consider functionality, systems and the entire lifecycle, the importance of implementing SPSD in the organisation with control over the offering conception and its design was identified (Laurent and Duckers, 2000; Shapiro and White, 1997; Morton, 1999; Charter et al, 2001; Croner, 2000). In light of the supply chain nature of offering development, the incorporation of key supply and value chain organisations e.g. suppliers to customers in the implementation process and supply chain management of these was also included (McAloone, 2000; Brezet et al, 2001; Ecolife, 2002; Charter, 2001; Dobes and Majer, 2002; DEFRA, 2002; Phelan, 2002; Meinders, 1999; Stevels, 2000; Simonsson and Barthel, 2002). For these reasons, SPSD shifts the focus for developing sustainable offerings to the supply and value chain rather than on individual companies alone, thereby engaging a wider group of key supply chain stakeholders. SPSD implementation activities are targeted based on the supply chain role and in particular the control a company has over the offering development stages key to sustainability improvements. This shift in focus away from an individual company alone (which traditional environmental performance improvement methods target) to the offering supply chain is a paradigm shift in how we apply sustainability approaches in product and/or service development.

- In addition to the criteria identified as necessary for achieving environmental and social benefits, a range of elements relating to meeting additional industry requirements and facilitating the implementation in order to achieve a more sustainable result were incorporated to include:-

  ⇒ The SPSD structure itself is a practical, qualitative framework of suggested actions backed by supporting information and a toolbox. It is a flexible approach designed to be customised to the company offering, culture and existing offering development systems.

  ⇒ A strategic approach with the development of sustainable products and/or services as a corporate aim which is integrated into existing business systems and their performance targets is advocated.

  ⇒ Guidance on effective organisation, management, planning, resources and communication internally and across the supply chain is provided

  ⇒ Relevant introductory and ongoing information to engage and support the implementation (to include the business case for implementing SPSD, legal and market drivers, industry case examples, support tools, SPSD information database) is incorporated in the implementation process.

  ⇒ To facilitate effective communication, using business language suited to the company/industry culture and minimising new jargon is advocated.

The new SPSD approach brings all these elements together for the first time to provide an industry support for developing sustainable offerings. This incorporates a wide range of strategies for maximising environmental and social performance in offerings and does not focus on specific strategies in isolation e.g. PSS or eco-efficiency which other approaches tend to do. SPSD brings together the strategies with the aim of applying those that will maximise the sustainability of the offering.

The shift in language illustrated in the SPSD term and approach is important to moving towards the development of more sustainable offerings. For example, the shift from

"products" to "offerings" reflects the shift from products to functions and opening up the options for provision of these functions by offerings – be they services, PSS or products. The use of "sustainable" reflects that the goal is sustainability not just reducing the environmental impact. SPSD starts with a function and determines the most sustainable way to provide it. This is a shift from starting with a product and finding the most eco-efficient way to provide it. Even in terms of language, this shifts the focus and provides a starting point for considering the functional, systems and sustainability related innovations identified for achieving significant environmental and social improvements.

11.2.4 SPSD Evaluation and Contribution to Sustainability

The evaluation of SPSD implementation as a support to develop sustainable offerings in ten live cases, resulted in nine offerings with TBL sustainability benefits (three PSS and six products) going into commercial operation, with one case not developing an offering due to irresolvable technical feasibility problems. The evaluation investigated research questions 9 and 10 and the results were interpreted in terms of the sustainability impacts of the offering resulting and the feedback from the users. Business advantages and disadvantages associated with implementing SPSD as a support for developing sustainable offerings were also observed from the experiences. The business advantages varied per case but included improved offering functionality, competitive advantage, new business opportunities, improved supplier and customer relationships, capability building and improved corporate reputation. The business disadvantages included increased resource requirements in terms of personnel and their associated time costs. Other negative features were difficulties in understanding new concepts e.g. the focus on functionality and considering alternative options for its provision, consideration of the wider systems the likely offering would operate in and integrating environmental and social criteria into the business strategy, in particular from company personnel in non environmental and social related business functions. Based on the evaluation results, improvements were identified and incorporated in the revision of the SPSD approach subsequently documented as the SPSD guide. Overall, the feedback from the companies concluded that the SPSD approach was practically useful and effective as a support for developing sustainable offerings. The

contribution of the SPSD process or not, towards developing an offering with TBL sustainability benefits was analysed. This showed key elements in the SPSD approach contributing towards the development of a more sustainable offering, as well as a range of external factors impacting the extent sustainability benefits were achieved.

11.2.4.1 Key Elements of the SPSD Approach Contributing Towards Sustainability

Based on the sustainability results and experiences of the companies, it was determined that implementing the SPSD approach did contribute towards developing offerings with TBL sustainability benefits. In terms of supports for industry to develop more sustainable offerings, **Table 11.1** illustrates the key elements of the SPSD approach the evaluation showed to be contributing towards developing a more sustainable offering. These can be concluded as contributing factors towards the development of products and /or services which prevent, or minimise adverse sustainability impacts as well as incorporating industry requirements (i.e. defined as effective SPSD implementation).

Table 11.1Key Elements of the SPSD Approach Contributing Towards Developing a More Sustainable Offering

Strategy & Integration
Strategic commitment to developing a sustainable offering and integration into business systems as relevant to the company structure, to facilitate buy in and co-operation in the implementing company.
Information
Provision of introductory supporting information and ongoing provision of information, especially regarding the new concepts relating to functionality and systems issues.
Integrated multidisciplinary team to include supply chain stakeholders
The incorporation of a multidisciplinary team incorporating personnel from the business functions in the company responsible for the implementation and key supply chain stakeholders e.g. suppliers and customers from the Concept Development stage. This provided more information to enable greater scope in terms of identifying more sustainable options and enabled quicker assessment of the feasibility of the options.

SPSD Expertise
SPSD expertise on the SPSD process implementation stages and concepts provided by the SPSD mentor and environmental consultants.
Incorporating environmental and social criteria
Incorporating TBL sustainability criteria in the offering development in order to improve sustainability in terms of environmental, social and economic benefits. In particular, the Concept Development stage of the SPSD implementation incorporates identifying, assessing and aiming to maximise the opportunities for preventing or minimising environmental and social impacts of the offering, hence environmental and social benefits were expected.
Targeting SPSD at organisations with design control of final offering
Implementation of SPSD by the company with control over the final offering design is important to maximising the sustainability improvements associated with consideration of alternatives for providing the functionality and assessing the impacts associated with the systems in which the end offering interacts. Focusing on one component of an overall offering limited the sustainability improvements possible in two cases[6].
Functionality, Systems, all lifecycle stages and a closed loop approach
Incorporating the Concept Development phase, gave the opportunity to identify options for the provision of a more sustainable way to provide a required functionality. The contribution from assessing the functionality, considering alternative ways to provide it (e.g. services and PSS), incorporating all lifecycle stages, using a closed loop approach and including the impacts associated with the offerings wider systems interaction, towards developing a more sustainable offering varied across the cases and contributed mainly to improving environmental performance. The experiences associated with obtaining a more sustainable result by focusing on meeting the human need required, as distinct from the end user requirement, was not tested in the cases. This was because all the companies were focused on providing a functionality to meet an end user requirement (their customers) as distinct from meeting a human need. This was observed as a different type of need and would require testing in future research. In the cases where the initiating companies were in control of the end offering and were open to considering an alternative way of delivering the function required, consideration of these aspects did improve the environmental performance of the final offering. For example, cases 3 and 4 achieved significant environmental benefit compared to their previous offerings by providing them through a PSS. Both cases highlighted that consideration of this option would not have occurred had they not considered the functionality required by their end user, the wider systems interaction, all lifecycle stages and aimed for a closed loop approach.

[6] See **Chapter 9** for further information.

The following elements of the SPSD process were identified as useful, effective and contributing to a successful implementation (but not necessarily a more sustainable offering):-

Organisation

- ❑ role of the project manager to co-ordinate and drive the implementation ;

Language/Communication

- ❑ use of recognised business language and minimisation of new jargon to facilitate effective communication.

11.2.4.2 Influencing Factors Limiting Sustainability Benefits

While offerings with TBL sustainability benefits resulted, this was not achieved to the same extent in all cases. Environmental benefits were observed in nine offerings but social benefits only resulted in six offerings with the remaining three cases having social impact unchanged. The environmental benefits were achieved in the most cases and to the greatest extent. After this, economic and then social benefits were achieved. Eight offerings had economic benefits with one case having economic impact unchanged. In addition to the SPSD implementation process, a range of alternative factors were identified from the user experiences as influencing the resulting sustainability benefits and the extent to which these were achieved. These influencing factors are summarised below:-

- ❑ When integrating traditional criteria with environmental and social criteria, different priority weightings were given to the criteria based on the company requirements. A higher priority weighting was given to meeting offering criteria such as customer requirements, market demand, cost and current compliance obligations compared to non compliance related environmental and social criteria.

- ❑ Outside of environmental compliance requirements, an association between improving efficiencies and resulting cost benefits was observed to determine which environmental improvements were made. This relates to higher priorities being

allocated to economic benefit compared to non compliance related environmental benefit.

- There is a lack of drivers and a business environment conducive to motivating companies to start by considering the function to meet a human need, consider all lifecycle stages in a closed loop cradle to cradle approach and incorporate wider systems interactions. The extent to which these SPSD aspects can be incorporated in offering development is limited by this, however, their incorporation is one part of the overall solution and should be considered in offering development. Without the wider infrastructure, drivers, business and consumer models, the contribution to a more sustainable offering that considering these in offering development makes is limited. It is proposed that if (and when?) these wider elements are in place, their consideration as part of the offering development process would enable a greater contribution to maximizing the environmental and social performance of offerings.

- There is a lack of drivers for companies to consider the environmental impacts across the entire lifecycle, as distinct from focusing on specific lifecycle stages e.g. end of life or raw materials. Current legal and market drivers aimed at environmental performance improvement focus on reducing the environmental impacts of specific lifecycle stages e.g. end of life in the WEEE directive for electronic equipment[7] , Packaging Directive[8] for packaging and ELV Directive for vehicles[9], or raw materials in the RoHS Directive[10] for hazardous substances used in electronics. While policy initiatives e.g. Integrated Product Policy (EC, 2001c; EC, 2003) and UNEP/SETAC Life Cycle Initiative (UNEP/SETAC, 2002) advocate Life Cycle Thinking incorporating all lifecycle stages, the case companies did not see these as drivers to implement this approach. This lack of drivers resulted in certain lifecycle stages (e.g.

[7] Council Directive on 2002/96/EC Waste from Electrical and Electronic Equipment (EC, 2003a).
[8] Council Directive 94/62/EC on Packaging and Packaging Waste (EC, 1994).
[9] Council Directive 2000/53/EC on End-of Life Vehicles (ELV) (EC, 2000a).
[10] Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) (EC, 2003b).

raw material acquisition) being perceived as outside the scope of the provider's responsibility.

- Difficulty in gaining accurate information on alternative raw materials, components and assemblies from supply chain companies and other sources were limiting factors in identifying and assessing potentially more sustainable options.

- There are increased drivers for environmental improvements compared to social ones. No cases stated explicit drivers to improve social performance, outside of employee health and safety related drivers.

- Excluding health and safety related social impacts, there is increased comfort and a sense of responsibility for considering environmental impacts compared to social, especially for social impacts associated with supply chain activities in other countries. A lack of drivers for the offering provider to take responsibility for social issues outside of the companies plant and locality and hence a reluctance to incorporate global social impacts occurring along their supply chains was identified as a feature limiting incorporation of social impact criteria in offering development in practice.

- A further limiting feature was difficulty in obtaining information to fully assess the social impacts across all lifecycle stages.

The SPSD implementation process provides guidance and supports aimed at achieving a more sustainable result. The other influencing factors are important to determining the extent to which the supports and recommendations are fully implemented, as well as the sustainability of the final offering.

A lack of drivers is seen as a significant barrier for companies towards motivation to develop more sustainable offerings. In particular, the influences relating to social impacts highlight a challenge on how to get companies to embrace the wider social dimension of

sustainability when there is a lack of external drivers to do this. As limited social impact reduction was achieved compared to environmental, incorporation of the full extent of social criteria in the SPSD approach requires further testing in future research.

The influencing factors identified are outside of the direct scope of industry implementation supports e.g. SPSD and relate to the wider business environment necessary for driving and sustaining a requirement for more sustainable offerings in the first place. In investigating the overall problem of how to reduce the adverse sustainability impacts of products, criteria for effective SPSD implementation and in the case evaluations, the importance of these external factors in terms of moving towards SCP and Sustainable Development was highlighted. Solutions aimed at reducing the adverse sustainability impacts of production and consumption involve a diverse range of problems, policies, instruments and stakeholders (Davidsson, 2002; Ryder, 2004). The external SPSD criteria highlight the wider aspects that need to be in place e.g. push & pull factors, in addition to implementation supports, to enable SCP. Increased pressures from legal and market drivers (especially from customers) were identified as necessary to motivate industry to develop sustainable products and/or services (McAloone, 2000; Dewberry, 1996; Stevels, 2000, Hanssen, 1997, van Hemel, 2002). The UK *BSI* survey of SPD type industry activities showed external drivers e.g. legislation as the most common factor for initiating and maintaining these activities (Simonsson and Barthel, 2002). Green procurement requirements, financial instruments and labeling are examples of advocated market initiatives (EC, 2003 ;EC, 2003e) The need for new business and consumer models involving a much wider group of stakeholders to support the transition towards provision of functionality as distinct from products, through system based offerings was identified (Mont, 2002; Dobes and Majer, 2002; Brezet et al, 2001). These models feature the following characteristics:-

- Business success not being based on the bottom line alone (Braungart, 2002; Winslow, 2002; Elkington, 1997, Hawkens et al, 1999);
- A time factor shift to focus on longer term profit vs. short term (Brezet et al, 2001);

- Business coalitions, networking and interaction with a wider group of stakeholders (Dobes and Majer, 2002; Brezet et al, 2001);
- Greater consumer involvement, education and information to shift the mindset of consumers from being owners of products to being users of system offerings (products, services or PSS) (Mont, 2002).

The external criteria show that there are a range of elements necessary for effective SPSD implementation. Developing SPSD concepts and industry supports focuses on one aspect of the problem – production of products and/or services in industry – and is one element contributing towards a more sustainable solution. It shifts the focus from the individual company level, to the supply and value chain level. In the wider business and consumer models suggested for SCP, the focus needs to shift to engage the wider institutional stakeholders with networked interaction (Dobes and Majer, 2002; Brezet et al, 2001; Ryder, 2004). The role of these external factors and the importance of creating the necessary business environment for developing sustainable offerings such that approaches like the new SPSD can be truly effective hold many opportunities for further research.

In addition to these influencing factors, the evaluation highlighted that one of the criteria incorporated in SPSD for effective implementation can limit the environmental and social benefits of the final offering. In the nine completed cases, integrating environment and social criteria with traditional criteria resulted in an offering being developed which was not the most environmentally sound and socially responsible option identified during implementation. The completed nine cases resulted in more sustainable offerings, but not the most sustainable offering identified during the sustainability assessment part of the SPSD process. In the case evaluations, criteria such as cost, technical feasibility, lack of raw material options and meeting customer requirements all resulted in a more environmentally sound option not being developed further. This is a limitation of the SPSD approach in terms of achieving the most environmentally sound and socially responsible offering, but is seen as necessary for effective implementation as incorporating traditional criteria was identified as a key industry requirement for obtaining an offering which is feasible in terms of all offering criteria. If industry requirements are to be met, this

limitation is unavoidable at present as meeting the traditional criteria is necessary to product and/or service providers working in a market economy. Perhaps in a less economically dominated paradigm where value is measured also by non economic parameters and improved technology options are available, greater environmental benefits could be achieved. The new business and consumer models highlighted as external criteria necessary for SPSD effective implementation identified business success being measured by generation of community wealth, protection and restoration of natural systems and leadership as distinct from the bottom line alone (Braungart, 2002; Winslow, 2002; Elkington, 1997, Hawkens et al, 1999). Further, innovations in technology aimed at providing raw materials and technical feasibility to maximize environmental performance are required (Brezet, 2004; Ryder, 20004). It can be concluded that the SPSD process is a support for the development of more sustainable offerings that are feasible, but not necessarily the most environmentally sound and socially responsible one. This illustrates limitations in the sustainability concept itself whereby integrating economic issues with environment and social issues can mean a compromise on achieving the best environmental and social outcome.

11.3 RESEARCH CRITIQUE

The research strategy and method was designed and used to conduct the research[11]. The critique of how this research method worked in practice is discussed in this section to include:-

- Quality Control;
- Limitations of the research method;
- Skills learnt and dissemination of research results.

Due to the diversity of the research questions to be answered, multiple research strategies to include literature review, semi structured interviews, participant observation and case study research were utilised in the research method (Creswell, 2002; Yin, 2003). In hindsight, this mixture of research techniques, while having some limitations was appropriate and

[11] The research method is detailed in **Chapter 2.**

successful in enabling the research questions to be investigated and aim and objectives to be achieved in a rigorous and reliable way. The benefits achieved outweighed the limitations.

The access enabled by the researcher's practitioner role to companies, practitioners and policy makers on topics relevant to developing sustainable products and services facilitated the research. Unique and unrivalled access to live test evaluation companies, enabled a participant observation approach whereby the researcher was able to access events or groups otherwise inaccessible (Yin, 2003). This provided real life data and experiences invaluable to the research and enabled a unique contribution to original research. As discussed in **Chapter 2**, potential quality control issues e.g. the introduction of bias associated with practitioner experience were acknowledged from the beginning of the research and the quality controls incorporated to manage this were successful and the advantages of the participant observation outweighed any potential disadvantages. Combining practitioner experience with academic research was seen as a hybrid research approach. Using this hybrid approach enabled the development of the new SPSD approach to a scientifically rigorous high level while still being practical for implementation in industrial companies. This approach provided a balance between academic rigorous thinking, practitioner and industry input, all of which were key elements for achieving the research aim.

11.3.1 Quality Control

The quality controls used included:-

- A specific research method to conduct the research which was suitably updated on an ongoing basis in line with the research evolution. The feedback and rework of the research method was invaluable as it ensured real results were taken on board. The maintenance of a process document throughout the research to chart the evolution of the research aim, objectives, questions, strategy, key developments and contributions

to knowledge was an important quality control. This enabled an accurate basis for the research, with clear questions (Yin, 2003).

- Multiple sources of evidence to validate one source with another, as available, in order to encourage convergent lines of inquiry (Yin, 2003) to ensure the reliability of the data collection and analysis.

- Establishment of a chain of evidence for construct validity and increasing reliability of the information generated. In particular, for the case tests, the use of a case study protocol (to document the overall case study research process), case study database (to document the data collected) and case study reports (to document the analysis and final results) provided a chain of evidence leading from the case study questions to the conclusions.

The role of these quality controls in ensuring the quality of the research in terms of the following four tests for quality of empirical social science research are detailed in **Chapter 2, 2.3**:-

- Construct Validity
- Internal Validity
- External Validity
- Reliability (Creswell, 2002, Yin, 2003).

Overall, the quality controls were successful in practice at ensuring reliability and validity. In particular, the controls introduced to manage the bias which can be associated with practitioner experience and use of a participant observation approach worked well. Participant observation as a source of evidence and data collection technique was identified as having many research advantages regarding case study research, but also one disadvantage in that potential biases can be introduced due to the researcher's manipulation

of events (Yin, 2003)[12]. Practical experience in the research topic could introduce bias through preconceived notions lacking objectivity and a rigorous basis and participation could potentially manipulate the events. Two quality controls were incorporated into the research method designed to control this bias. First, multiple data sources were used, only one of which was participant observation. The participant observation data collection technique was backed up by:-

- ❑ semi structured interviews with the project manager for each case;
- ❑ a report of each case developed by the implementation team (excluding the researcher);
- ❑ additional documents and information on the case;
- ❑ the final offering;
- ❑ direct observation.

The sources include the six sources of information (documentation, archival records, interviews, direct observation and participant observation and physical artifacts) recommended for case study research (Yin, 2003). The data sources were also multiple involving the project manager in the semi structured interviews, as well as the mainly multidisciplinary team participants per case obtained through the researcher's participant observation role at regular meetings. As the case evaluations lasted over an extended period of time, there was much opportunity for accessing data throughout all stages of SPSD implementation and under different conditions. This provided additional opportunities for data validation as well as alternative/rival explanations for why aspects of the SPSD approach did, or did not work effectively, to be investigated. The second data control was defining and using the analytic strategy defining priorities for what to analyse, why and criteria for interpreting the findings in the case study protocol. This enabled the data to be treated fairly, producing compelling analytic conclusions and ruling out alternative interpretations (Yin, 2003).

[12] The benefits and drawbacks of participant observation as a data collection technique were already discussed in **Chapter 2**.

11.3.2 Limitations of the Research Method

Limitations were identified for some of the individual data sources and collection techniques. Overall, the choice of data sources were limited to those available relevant to the research topic and its wider application. Every effort was made to source the most suitable data sources to ensure an objective investigation of the research questions could be conducted.

As part of the literature data sources, documented company examples of implementation approaches relevant to developing sustainable products and services were used. Few well documented, comprehensive company examples were available. Also, the majority of those available focused on improving the environmental performance of products rather than a more holistic approach incorporating the innovations identified as important to significant environmental and social improvements. This limited the choice of this data source. Additional criteria used to choose the documented examples were:-

- access to company personnel for interviews,
- representation of a range of industry sectors, company sizes and roles in the supply chain.

These criteria further limited the choice resulting in eight documented company examples[13] being used which met all these criteria. As a result not all industry sectors are represented, only the OEM role is represented in these documented examples and only two of the companies are SMEs. This is because those companies innovative enough to be implementing these types of approaches to date are mainly large OEMs. 17 additional companies[14] practicing approaches relevant to developing sustainable products and services (again mainly environment focused), but which did not have documented examples were also used as data sources. These provided five more SMEs and three examples of non OEM supply chain roles. The combination of the documented and non documented company data

[13] Data Type 1.
[14] Data Type 2.

sources improved the representative nature of this data source. With respect to identifying industry requirements for SPSD, in addition to the data sources already described an additional 16 companies[15] commencing implementation approaches relevant to developing sustainable product and services were interviewed. Their addition added diversity in terms of industry sectors, size and role in the supply chain (as not all companies were OEMs and all were SMEs), regarding information on industry requirements.

In addition to literature, the data sources included practitioners (in industrial companies and consultancy), academics and policy makers[16] with expertise and experience relevant to the research totalling 106 data sources. The most suitable experts to answer the questions were purposefully chosen based on relevant knowledge and experience. The information was obtained either in the form of a semi structured, expert interview (Flick 1998) in person, over the phone or by email, where meeting in person was not possible and questionnaires were used. Questionnaires are useful, but do have weaknesses. First, if a question is not answered this leaves a gap in the data required. For the semi structured interview, the researcher was asking the questions as distinct from a mailed questionnaire survey, so this ensured that all questions were asked. In the email survey, the data sources completed the survey independently. In this case a minority of data sources did leave questions unanswered. The second weakness of questionnaires is that the respondents can interprete a question differently and this can impact the reliability of the data received. To minimise this, questions in the questionnaires were designed to clearly state the information required and to minimise the possibility for confusion or miss-interpretation. Also, a space for additional comments was included on both questionnaires to give an opportunity to get a further overview of the respondents thinking. For the semi structured interviews, the possibility of leading the interviewee to gain the answers expected rather than objective factual responses can adversely impact the reliability of the data. The questionnaire was developed to use open ended questions as distinct from leading questions to get the actual view of the interviewee. Notes were taken during interviews and answers confirmed verbally with the interviewee to confirm accuracy.

[15] Data Type 4.
[16] Data Type 3.

When using a mailed survey there can be difficulties getting responses from the data sources required. In this case the email survey questionnaire was sent to 67 data sources, in anticipation of only getting a percentage of replies back. A deadline was specified for responses and reminders were sent to encourage replies. 48 responses were received to the email survey questionnaire. This issue did not arise for the semi structured interviews as all of these (80) were set up, co-ordinated and completed by the researcher.

A limitation of the data from the email survey was identified. The email survey questionnaire was used after many data sources had been interviewed and literature reviewed. At this stage, some factors for effective SPSD implementation had been identified. As such, in addition to requesting the required information, the email survey respondents were asked to agree/disagree and rank seven factors already identified from the research to date for effective implementation. This question was included on the questionnaire after the questions on what factors the respondent believed were necessary for effective SPSD implementation, so as not to influence respondents. As only seven of what eventually became the 16 internal and external criteria for effective SPSD implementation were included, the responses to the ranking were not used as data sources for determining the criteria. Instead, the answers given to the question *"What factors do you think are necessary for effectively implementing SPSD in manufacturing industry?"* were solely used to collect this information from the emailed data sources. The answers to the ranking question were included only as an additional indicator illustrating ranking in order of importance of factors already highlighted by the respondents. This was useful and gave a breath of perspective on views, but could not be used as an accurate indicator for ranking of all criteria as only some were included on the questionnaire. In hindsight, including a question which required ranking of some factors when all had not yet been identified was not suitable to generating accurate data on which were seen as more important than others. Now that the criteria have been established from this research, further research could investigate the ranking in terms of importance of each of the criteria among the data sources used.

11.3.2.1 SPSD Case Evaluation Companies

The choice of companies in which to evaluate SPSD implementation was limited to those interested in participating in a test which focused on improving the sustainability of products and/or services. Having the opportunity to evaluate SPSD implementation in a live company situation was invaluable to the research obtained, however, the choice of test companies was limited to those available and this limited the extent to which certain aspects of the approach could be tested. Overall, the benefits of the live case research outweighed these limitations. This also has implications for the generalisability of the evaluation results. Factors such as industry sector, likely offering proposed, organisation size, role in the supply chain, supply chain organisations, geographic locations, motivation and commitment to developing a sustainable offering were relevant to determining the extent to which a more sustainable offering could be developed. In order to have as representative a group of case examples as were available in the first place, the selection criteria included diversity in sectors, products and/or services, organisation sizes and roles in the supply chain. This prevented bias which might be introduced by test factors only pertinent to one sector, for example. Multiple cases were chosen as this had more substantial analytical benefits due to the possibility of direct replication. Of those companies interested to participate, the ten chosen had characteristics that would enable as representative a group as was available. Both the varying contexts and large number of cases were seen as important quality control factors (Yin, 2003).

Irrespective of the representativeness, the influencing factors already discussed in section **11.2.4**, were also going to determine the extent to which aspects of SPSD implementation could be tested. These relate mainly to testing of functionality to meet a human need, wider systems interaction, full extent of social impacts and involvement of customers as stakeholders.

First, the ability to consider proving a functionality to meet a human need and wider systems interaction were limited by the evaluation company and supply chain. For six cases, each company taking responsibility for SPSD implementation was intent to focus on

improving the sustainability of an existing offering – this limited the opportunities for functional and systems innovations that could be incorporated. For those open to producing a new offering (four cases) more scope to test the functional and systems innovations was available. In spite of these limitations with the evaluation cases, the evaluation was a good starting point to determining that the new SPSD approach does contribute to developing more sustainable offerings. In light of the limitations that the test cases introduce, future testing should be conducted and the test subjects chosen to ensure all aspects, in particular the functional and systems innovations could be tested to a greater extent. This would not have to be limited to testing companies in offering supply chains, but based on the systems involved could aim to involve the systems stakeholders. This is outside of the scope of this research, however, testing at this wider systems stakeholder level would be a logical next step in future research in this area.

Second, while incorporation of social impact was tested in the evaluation cases, the extent of this testing was limited by the influencing factors and by the case companies. The influencing factors have already been discussed. Third, involvement of customers was limited to three of the cases evaluated. This was a limitation to testing the experiences associated with the involvement of end customers as key stakeholders customers. The involvement of customers in a range of case contexts would require further testing.

In terms of generalisability of the evaluation case results, in light of the large number of cases, generalizations could be made based on cross case similarity of experiences and results. Each case was analysed individually in terms of the defined criteria for interpreting the findings and for success and failure. Further, replication logic was used to show similar features or differences between case studies and to be a basis for generalising from the results of all case examples (Yin, 2003). However, the case evaluations also highlighted that individual influencing factors as already discussed, impact the outcome. These influencing factors can have general application e.g. a lack of drivers for improving the social performance of products and services will impact many companies producing different offerings and operating in different sectors. They can also be specific to the particular situation per offering, sector and involved companies.

11.3.3 Skills Learnt and Dissemination of Research Results

The research project has been a sustained, in depth study on developing sustainable products and services in industry and the wider issues relevant to this. It has involved learning a range of skills relating to conducting rigorous scientific research, presenting and teaching, as well as the direct research and related wider topics. Interaction with other multidisciplinary research colleagues facilitated understanding the research process and provided interaction on a broad range of subject matter. In addition to the direct research, ongoing communication, dissemination of the research and teaching has been a key focus. In order to debate and disseminate information on this research, one paper has been published in the *Journal of Cleaner Production*, nine presentations have been given at conferences with associated papers published in the conference proceedings and MSc lectures given. Details on these papers, presentations and lectures are in **Appendix 1**. Two abstracts for future papers on the final research results have been submitted to the *Journal of Cleaner Production*. The researcher is also working on a *UNEP/SETAC* task force to develop an industry handbook on Life Cycle Management (UNEP/SETAC, 2004). All of the opportunities to communicate the research enabled a greater understanding of the research itself, areas that required further thought and how to effectively communicate with different audiences.

11.4 RECOMMENDATIONS FOR FURTHER RESEARCH

A number of recommendations for further research have been highlighted in the discussion and are summarised below. These areas of research are outside of the scope of this research project.

- In light of the limitations identified with evaluating the functional, systems, social impact and involvement of key stakeholders aspects of SPSD, based on the test cases available within this research, future research could further test these aspects. Where availability and choice of live test examples is not limited, the test examples should be chosen to ensure these aspects are fully tested in light of their contribution to developing more sustainable offerings.

- SPSD incorporates the opportunity to consider the most sustainable way to provide the functionality to meet a human need required. Consideration of this issue raises many questions regarding human needs. For example, beyond survival based needs, what are human needs and how do we distinguish between needs and wants? The research highlighted that considering these issues provides an opportunity for obtaining a more sustainable offering, but that the extent this is considered is influenced by a range of external factors, in particular the company drivers and views on the human need or end user need that their offering is to provide. In all the evaluation cases, none of the functions to be provided were deemed as human needs but the companies viewed them as key functions to be provided to an end user. The impact of these external factors and the differing views on what is a human "need" as distinct from a "want" and the implications for sustainability are further areas of research.

- Investigate the ranking in terms of importance of the criteria for effective SPSD implementation.

- In the case evaluations SPSD expertise was included as part of the SPSD implementation process. This is built into the SPSD approach and guide as a recommended part of the implementation. Testing of the SPSD guide as a standalone support without SPSD expertise could be conducted as future research.

- Research on the technology innovations required to realize workable alternatives in terms of raw materials and technical feasibility to maximize environmental benefit in closed loop approaches is a broad area of existing research. Ongoing research development in this area is one part of the overall solution towards developing more sustainable offerings.

"GNP measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion to country. It measures everything, in short, except that which makes life worthwhile."
Robert F. Kennedy

CHAPTER 12 CONCLUSIONS

12.1 INTRODUCTION

This research project has contributed a solution towards the problem that products at all stages of their lifecycle can cause adverse environmental and social impacts. The research highlighted that this is a significant problem whose solution has many facets and impacts many stakeholders and focused on one element – facilitating the development of more sustainable offerings by industry. The research aim and objectives were successfully achieved. The key contributions to knowledge resulting are:-

- Identification of internal and external criteria for effective Sustainable Product and/or Service Development (SPSD) implementation to incorporate industry requirements and result in the production of products and/or services with reduced sustainability impacts.
- Identification and critical assessment of existing approaches relevant to developing sustainable products and/or services against the criteria for effective SPSD implementation.
- Development of the new SPSD approach and guide for industry.
- Case evaluation data from the live application of the SPSD approach in companies to include their results and experiences on using this approach to develop sustainable offerings.

Based on these contributions, the key conclusions, their importance, originality and how they advance the study of the subject are discussed in this chapter with recommendations for further actions.

12.2 CRITERIA FOR EFFECTIVE SPSD IMPLEMENTATION

The internal and external criteria for effective SPSD implementation contribute to the advancement of the research topic by providing knowledge on the criteria required to support the production of products and/or services with reduced sustainability impacts and incorporate industry requirements. This latter aspect facilitates practical use of the knowledge. The internal criteria provide knowledge in terms of the requirements relevant to an SPSD implementation approach for industry. The external criteria provide knowledge on the larger systems, infrastructure, policies and drivers relevant to promote the development of sustainable offerings in general, and involve a wider range of stakeholders, not just industry. The internal criteria relevant to an SPSD implementation approach were the key focus of this part of the research and used to develop the new SPSD approach. However, the external criteria were identified as an important part of the wider system elements necessary to drive industry and other stakeholders to consider developing sustainable offerings and create a conducive business environment. As such, they were identified as an important contribution to knowledge, outside the scope of the original research question. The criteria are original as they are based on the analysis of existing approaches, industry activities, drivers, requirements and factors necessary for effective SPSD implementation using multiple data sources (companies, academics, practitioners and policy makers) and literature. These criteria could be used by researchers, policy makers and practitioners in a range of applications relating to encouraging the development of sustainable products and services.

12.3 NEW SPSD APPROACH

In critically examining the existing status of activities, drivers, supports and criteria relevant to developing sustainable products and services, the need to develop a new approach involving a rethink of aspects of the existing knowledge base, was identified. The industry status is reflected in the following quotation:-

> *"Some companies have started ecodesign activities, but social and ethical aspects are not usually integrated into the product development process. At present, there*

> *is little guidance on the product implications of business sustainability and very little information on applying SPD"* (Charter and Tischner, 2001, p. 121).

The research did not identify any existing implementation approaches that met all the criteria for effective SPSD implementation and a lack of industry supports and activities for developing TBL sustainable offerings was identified. This resulted in the new SPSD approach. This research advances the sustainable product and services topic by creating a new support for industry for developing sustainable products and/or services. The new SPSD approach was designed to meet the requirements of business and industry in developing sustainable products and/or services and to provide formalised support, adding to what is currently available. Overall, this has resulted in the development of the new term SPSD and new SPSD approach (Maxwell and van der Vorst, 2003). SPSD builds on and develops the existing approaches e.g. EPD and SPD, in that it provides a formalised support for industry aimed at maximising sustainability (environmental, social and economic performance) in offering development.

12.4 SPSD CONTRIBUTION TO DEVELOPING MORE SUSTAINABLE OFFERINGS

The case evaluation data from the live implementation of SPSD in companies provides unique, live, company data on the sustainability impacts of the offerings resulting and the feedback from the users. The hybrid research approach incorporating participant observation and access to companies presented a unique opportunity to research SPSD implementation in real life situations generating live, new data. This included knowledge on the contribution the SPSD approach made towards supporting the development of a more sustainable offering, as well as the wider influencing factors involved which impacted the extent the recommendations for maximising sustainability in the SPSD approach were implemented and the sustainability of the final offering. As developing more sustainable offerings in industry is a relatively new area, the ability to test approaches and practically assess the effectiveness of the environmental and social improvements achieved is

important. Also it provides mainstream industry case examples to clarify the business, environmental and social cases to all stakeholders of which there is a significant need.

In terms of its contribution to developing a more sustainable offering, the new SPSD approach provides a framework of recommended actions that provide the opportunity to incorporate issues necessary to develop a more sustainable offering. This provides a formalised support to industry to better enable the development of sustainable offerings. The influencing factors identified are outside of the direct scope of industry supports e.g. SPSD and relate to the wider business environment necessary for driving and sustaining a requirement for more sustainable offerings in the first place. The influencing factors include the conflicts that can be associated with incorporating environmental and social criteria with traditional criteria, especially economic issues and technical feasibility and a lack of drivers to incorporate the issues key to making significant sustainability improvements. These highlight the limitations to developing and producing sustainable offerings associated with current market economy conflicts, lack of push and pull factors and technological innovations necessary to make more sustainable offerings a reality.

12.5 THE BIG PICTURE

In terms of the big picture, these influencing factors highlight that supports e.g. the new SPSD approach, are only one aspect of the sustainable production part of moving towards SCP and Sustainable Development. The problem statement analysis, the SPSD criteria, as well as case evaluation results illustrate some of the wider aspects required to support the development of sustainable offerings and ultimately SCP. Solutions encompassing varied aspects e.g. physical infrastucture, technology innovations, diverse policy, legal and market instruments, new business and consumer models all incorporating the factors necessary to motivate producers and consumers, and involving wide system level stakeholder engagement has been highlighted. As the SPSD case evaluations illustrated, without these wider aspects, the contribution to a more sustainable offering that can be made through using industry support approaches such as SPSD is limited. This provides new knowledge for the bigger picture solution of enabling SCP.

Fundamental limitations about the TBL sustainability and Sustainable Development concepts in terms of maximising environmental and social performance by integrating environmental and social criteria with economic issues were also highlighted by the research. At an economic level, limitations to this were seen due to commercial feasibility requirements being a necessity in a market economy. Recent SCP debate has also highlighted failures in the capital markets system and an associated inherent conflict with business as key barriers to SCP (Brezet, 2004, Young, 2004, Ryder, 2004). While the TBL integration facilitates the practical implementation of the Sustainable Development concept in the market economy, it is unlikely to achieve the environmental and social performance required, in particular the minimum Factor 10 environmental improvement advocated as necessary to support an expected 8 billion population by 2040 (Cramer, 1997; Croner, 2000; Charter, 1999; European Foundation, 1997; Hawkens et al, 1999; Foxon et al, 2003). This requires a rethink of the TBL sustainability concept and its ability to deliver the environmental and social improvements required. This has fundamental implications for how we measure value, wealth, success and the role of economic and other indicators to do this. The role of current indicators e.g. Gross National Product (GNP) or Gross Domestic Product (GDP)[1] as measures of economic success based on the value of goods and services produced in a country per annum pose conflicts in terms of SCP and Sustainable Development. Incorporation of other indicators, to include community wealth, environmental and social capital and how we ensure the required prioritisation of these factors in practice, need to be determined (Braungart, 2002, Winslow, 2002, Elkington, 1997, Hawkens et al, 1999; (WWI, 2004). A re-evaluation of human needs and wants is part of this equation with new definitions for how consumers and producers measure value reflected in new business and consumer models. Only recently, amendments to the EU Sustainable Development Strategy to include elements such as quality of life and resource use in the methodology currently used for assessing growth and productivity have been recommended (ENDS, 2004a; Ryder, 2004; EC, 2001a).

[1] GNP is the US indicator and GDP is the European.

The research conclusions highlight recommendations for a range of stakeholders – policy makers, researchers, industry, consumers, NGOs etc. The specific research recommendations have already been discussed[2]. From a policy context, a review of the TBL Sustainable Development concept and developing SCP policies in terms of their ability to achieve the required environmental and social results is recommended for international policy makers e.g. UNEP and at EU level through the EC (e.g. DG Environment and DG Enterprise). The market economy conflict needs greater analysis and alternatives to be considered. To bring together all the parts of the jigsaw necessary to move towards SCP, it is recommended that a wide range of stakeholders, in particular policy makers, focus on creating the wider business environment encompassing the push and pull factors necessary to motivate producers and consumers to develop and demand more sustainable offerings. This encompasses short and long term agendas relating to infrastructure, technology, business and consumer models and changing consumer behaviour.

Overall, the contributions to knowledge from this research advance the study of developing sustainable products and services in industry. They contribute new knowledge to the research topic, as well as the new SPSD approach and guide that can be used by industry as a support for the development of sustainable offerings. The research rethinks aspects of what has come before to create new areas, approaches and questions on how we can develop more sustainable offerings and the bigger picture of SCP. In the overall problem of the adverse sustainability impacts that can be caused by production and consumption, the new SPSD approach and guide can be used to facilitate the development and production of more sustainable offerings by industry – one aspect towards maximising environmental and social performance in the way we meet our human needs.

[2] **See Chapter 11.**

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APPENDIX 1: PRESENTATIONS, CONFERENCES AND PAPERS

The following presentations/papers were given on the research project:-

- Maxwell, D. (2000), "Environmental Supports to SMEs", Sustainable Development, SMEs and New Enterprises, European Foundation for the Improvement of Living and Working Conditions, Oct. 12-13 2000, Dublin

- Maxwell, D. (2001a), "Eco-Design for Profit", Environmental Business Network at Sheffield University, 23-25 April, 2001, UK

- Maxwell, D. (2001b), "Improving your Business through Environmentally Superior Products", Enterprise Ireland conference & exhibit of ESPs, 30 May 2001, Ireland

- Maxwell, D. and van der Vorst, R. (2002), "Developing Sustainable Products and Services – the Irish Experience" , The 8th European Round Table on Cleaner Production 2002, Session: Cleaner Products and Services, 9-11 October 2002, Cork, Ireland

- Maxwell, D. and van der Vorst, R. (2002a); "Sustainable Products and Services" , Towards Sustainable Product Development #7, BSI Conference Centre, London, 28-29 October 2002

- Maxwell, D. and van der Vorst, R. (2003), "Developing Sustainable Products and Services", Journal of Cleaner Production, Volume 11, Issue 8, December 2003, pp. 883 -895, Received 18/11/02, Elsevier Press

- Maxwell, D., van der Vorst, R. and Sheate, W. (2003); : "Sustainable Innovation in Product and Service Development", Sustainable Innovation 03 - Towards Sustainable Product Development # 8, 28-29 October 2003, Stockholm, Sweden

- Maxwell, D., van der Vorst, R. and Sheate, W. (2004); "A Guide to Developing Sustainable Products and Services in Industry" , The 8th European Round Table on Sustainable Consumption and Production 2004, 12-14 May 2004, Bilbao, Spain

- Maxwell, D., van der Vorst, R. and Sheate, W. (2004)a, "Sustainable Product & Service Development in Industry" SusProNet Conference - Product Service Systems: Practical Value, 3 & 4 June 2004, Brussels, Belgium

In addition to the conferences listed above, the researcher attended the following conferences as part of the research:-

- Environmentally Superior Products, Enterprise Ireland, 31 March 1999, Dublin

- Towards Sustainable Product Design, 5th International Conference, Design Centre Stuttgart, 23-24 October 2000, Germany

- Blue Skies, Green Horizons, conference and exhibit of award winners from the International Design Resource Awards (IDRA), Industrial Research and Technology Unit, Design Directorate, February 2001, Belfast

- Eco-design for Commercial Advantage, London Institute for Mechanical Engineering, 28 June 2001

- Towards Sustainable Product Design # 6, The Netherlands, October 2001

- Electronics Goes Green, Germany, 6-8 September 2004.

Teaching on the research topic included the following:-

- Seminars on Sustainable Product and Service Development and Life Cycle Thinking were conducted for the *Pollution Management* and *Business & the Environment* options of the MSc in Environmental Technology at the Environmental Policy and Management Group, ***Imperial College London*** as follows:-

  ⇒ Pollution Management: 04 February 2002 ; 17 January 2003; 23 February 2004

  ⇒ Business & the Environment: 16 January & 14 March 2002 ; 12, 13 March 2003; 09 February and 18 March 2004

The following future papers are planned and abstracts have been accepted:-

- "Sustainable Product and Service Development in Industry", Journal of Clearer Production, Special Issue *Less Bad is Not Good Enough*, expected mid 2005

- "Functional and systems thinking within Sustainable Product and Service Development" Journal of Cleaner Production, Special Issue *Product Service Systems*, expected end 2005

APPENDIX 2: DATA TYPE 1-4

This appendix includes details of data types 1-4, email survey respondents and interviewees.

KEY:

Blue text = Email survey respondents : * = Interview

DATA TYPE 1: CHOSEN COMPANIES WITH ESTABLISHED, DOCUMENTED EXAMPLES RELEVANT TO SPSD				
ORGANISATION	**SECTOR**	**SIZE (large or SME)[1]**	**Supply Chain Role**	**CONTACTS**
Xerox	Electronics	Large	OEM	Kieran Phelan*, EHS Manager, Xerox Ireland
Philips Electronics Philips Semi Conductors	"	"	"	Dr. Herman Meinders* Prof. Dr. Ab Stevels Nils.de.Caluwe Dr. Chris Sherwin
Electrolux	"	"	"	Emma Larson, Philip Thompson
Rohner Textil AG	Healthcare	"	"	Albin Kaelin, MD*
IKEA, UK	Furniture	"	"	Charlie Brown*, Environmental Co-ordinator
Johnson & Johnson Ltd.	"	SME	"	Randolph T. Haviland, Manager R&D Worldwide Environmental Affairs Eunan Friel, MD Johnson & Johnson Ireland Dr. Karl Schmidt*, VP, Worldwide Environmental Affairs
Wilkhahn	Furniture	Large	"	Dr. Jochen Hahne* Sabine Skoez (moved as of 2000)*
Interface Europe	Textile	Large	"	Nigel Stansfield, Product Manager

[1] Large is defined as greater than 250 employees and SME is defined as 250 employees or less.

DATA TYPE 2: COMPANIES WITH EXPERIENCE RELEVANT TO SPSD BUT NOT WELL DOCUMENTED EXAMPLES				
ORGANISATION	**SECTOR**	**SIZE (large or SME)**	**Supply Chain Role**	**CONTACTS**
Abbott Ireland	Healthcare	Large	OEM	Tom McGauran, Product Design Manager*
Nike, Sustainable Product Design	Textile	"	"	Mary Ellen Smith, Director Darcy Winslow
Sony International, Environment Centre Europe	Electronics	"	"	Dr. Lutz Scheidt, Director Andrew Baynes (moved to Apple as of 2002)*
IBM, Environmental Programme, UK	ICT	"	"	Stephen Bushnell
LG Electronics Inc, Korea	Electronics	"	"	Jin-Han Kim*
Bristol-Myers Squibb, Germany	Healthcare	"	"	Ludwig Metz, Director Corporate Compliance Assurance Service
TRW Aeronautical Systems (Lucas Aerospace), UK	Engineering	"	Tier 1 supplier	Estelle Hook*, Project Manger HS & E in Design
Siemens AG	Electronics	"	OEM	Friedrich Kock, Environment Manager
Nokia Networks, UK	ICT	"	"	Andrew Strange*, Senior Designer
Varian Medical Systems	Healthcare	SME	"	John Peel *, MD
Avad Furniture, UK	Furniture	"	"	Andrew Mitchell*
Klinge Pharma, Ireland	Pharmaceuticals	"	"	Seamus Gethins, EHS Manager*
Gea-SOL, Slovenia (Solar Tile) EU Environmental Award Winner 2002)	Engineering	"	"	Aljosa Pajk*
TTS A/S, Denmark (Green traffic light) EU Environmental Award Winner 2002)	Engineering	"	"	Paul Nellemose, MD*
B&Q	DIY Retail	Large	Retailer	Claire Cooper, Social Responsibility Manager, UK Dr. Suzanne Jordan, Environmental Research Manager, UK*
Cargil Dow LL	Chemical	"	OEM	Michael O'Brien
Apple Computers International	ICT	"	OEM	Andrew Baynes, Environmental Affairs Manager Europe*

DATA TYPE 3: SPD SPECIALISTS (KEY SPD / EPD RESEARCH / RESOURCE ORGANISATIONS)	
ORGANISATION	**CONTACTS**
Delft University, Design for Sustainability Programme, The Netherlands	Prof. Dr. Han Brezet, Director, Design for Sustainability Programme Prof. Dr. Ab Stevels, Chair of Applied ecodesign Linda Roos, Researcher Casper Boks, Assistant Editor Journal of Sustainable Product Design
Delft University of Technology, Netherlands Industrial Design Engineering	Jan Carel Diehl, M.Sc Assistant Professor
Aries Environmental Innovation University Business Centre, The Netherlands	Marcel Crul, M.Sc.
University of Amsterdam & IDEA Consultants	Dr. Hans van Weenen*
TNO , Netherlands & SUS PRO NET Research Project	Dr. Arnold Tukker*
Centre for Design @ RMIT University, Australia	Dr. John Gertsakis*, Director Dr. Dominique Hess*
Centre for Sustainable Design, University of Surrey, UK, & South East Environmental Business Association (SEEBA), UK	Prof. Martin Charter*
University of Sheffield Ecodesign Department & Environmental Businesses Network (EBN) & EBN Ecodesign Club (since 2002 at ProActus Ltd)	Dr. Leigh Holloway*
The Open University, Design Innovation Group	Prof. Robin Roy*, Director of Design and Environment Dept.

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Goldsmiths College, Univeristy of London, Dept. of Design	Dr. Kate Fletcher Dr. Emma Dewberry*
Warwick Business School	Stéphane Laurent*
University of Karlskrona/Ronneby, Ecodesign programme @ Department of Mechanical Engineering	Sophie Byggeth*
Chalmers University of Technology and Göteborg University	Dr. John Holmberg* Dr. Ulrika Lundqvist
Sheffield Hallam University, Life Cycle Design Research Group	Dr. Matthew Simon
Manchester Metropolitan University, Design for Environment Research Group	Steve Poole
Technical University of Denmark, Department of Mechanical Engineering, Section For Engineering Design and Product Development	Dr. Tim McAloone
Cranfield University, International Ecotechnology Research Centre School of Industrial & Manufacturing Science	Prof. Stephen Evans Dr. Tracey Bhamra Frank van der Zwan
University of Galway, Galway Mayo Institute of Technology, CIMRU, DfE research group	Dr. Thomas Roche*
University of Limerick , Electronic Product Development Division	Prof. Phil Burton, Director
Materials Ireland Polymer Research Centre, Trinity College Dublin	Dr. Jenny Melia
University of Salford, Design and Innovation Research Group	Dr. Jo Heeley
University of Wales Swansea, European Business Management School, Ecodesign Programme	Dr. Frank O'Connor*
Tellus Institute, Business and Sustainability Group, USA	K. Shapiro Tom Votta, Senior Scientist
The Natural Step, Sweden	Dr. Karl-Henrik Robèrt
Bio-thinking International	Edwin Datschefski
Swedish Industrial Design Foundation, Stockholm	Torsten Dahlin*
Wuppertal Institute	Eco-Efficiency and Sustainable Enterprise Group Information Service
O2 Global Network and Netherlands Design Institute	Dr. Connie Bakker*
O2 France	Jean-Baptiste Puyou
Bio Intelligence Service	Véronique Monier
ZERI Foundation, Switzerland	Anna Ardin

Clean Technology Centre, Ireland	Noel Duffy*, Director Simon Wilkinson, WEEE Collection trials project co-ordinator Ireland
Cleaner Production Promotion Unit, University of Cork, Ireland	Aveen Henry*
SustainAbility	Nick Robinson
McDonagh Braungart (USA) & Braungart EPEA (Germany)	Michael Braungart*
Eramus University, Erasmus Center for Environmental Studies, The Netherlands	Prof. Nigel Roome, Chair of Sustainable Enterprise & Transformation
Erasmus University, Erasmus Center for Environmental Studies, The Netherlands	Prof. Jan Jap Bouma Ph.D.
Erasmus University, Erasmus Center for Environmental Studies, The Netherlands	Prof. Jacqueline Cramer
STENUM GmbH, Austria	Gudrun Engelhardt
JOANNEUM RESEARCH, Austria	Barbara Hammerl*
IHOBE, S.A. Spain	Ander Elgorriaga
SAT (Austrian Society For Systems Engineering And Automation), Austria	Bernd Kopacek
Sustainable Design Network & Sustainable Business Consultant	Dr. Mark Smith*
The Centre for the Management of Environmental & Social Responsibility (CMER), INSEAD, France	Dr. Kai Hockerts, Research Programme Manager
Ecologic Economic Research programme, Institute for Futures Studies and Technology Assessment (IZT), Berlin. (future studies and the analysis of sustainable products and services in the economy and society).	Siegfried Behrendt, co-ordinator
Centre for Clean Products and Technologies University of Tennesee	Prof. Don Huisingh Senior Scientist in Sutainable Development & Editor: Journal of Cleaner Production
International Institute for Industrial Environmental Economics, Lund University Latvian Pollution Prevention Centre/Vides Vadibas Tehnologijas Ltd.	Inga Belmane* Eco-forum Baltica project co-ordinator
International Institute for Industrial Environmental Economics, Lund University	Dr. Oksana Mont*
Product Life Institute, Geneva	Prof. Walter Stahel

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CONSULTANCIES INVOLVED WITH SPD/EPD	
ORGANISATION	**CONTACTS**
Syntens Amsterdam	Rene Hartman*
Kathalys	Prof. Han Brezet, Director
E©oconcept, Germany	Ursula Tischner*, Director
EDEN B.V.	Dr. Yorick Benjamin*, Director
PRé Product Ecology Consultants, The Netherlands	Michiel Oele
Eco Balance Sustainable Design Consultancy Pty Ltd, Australia	Kirsty Máté*, Managing Director
STORRM C.S., The Netherlands	Harry te Riele*, Research Consultant
Shot In The Dark, Centre For Environmental Communications, UK	Alan Olwen*, Managing Director
Lifecycling, The LCA Specialists, UK	Jeremy Hansell*, MD
AMT Ireland	Mary O'Heocha*, Manager
EMA International, Ireland	John Ryan*
Irish Productivity Centre, Ireland	Norbert Gallagher*
Altran Technologies (eLife Cycle Assessment in SMEs project/Cascade LCA), UK	Graham Adams*, Ecodesign consultant
Hydrometrics & Sustainable Industrial Park project, Ireland	John Lynch*
J. Ottman Consulting Inc, USA (Green Product Marketing)	Jacquelyn Ottman, President*
Five Winds International, Canada	Ralf Nielsen*, Manager
Price Waterhouse Coopers, Amsterdam	Ceres van Halen, Director
ProActus Ltd, UK	Dr. Leigh Holloway*
POLICY ORGANISATIONS WITH SPD/EPD INVOLVEMENT	
ORGANISATION	**CONTACTS**
European Commission DG Environment	Helen Donoghue Otto Linher*
Department of Enterprise, Trade and Employment, Ireland	Gerry Wrynn*
Environment Policy Dept., Enterprise Ireland, Ireland	M. Reilly*
Department of the Environment & Local Government, Ireland	Terry Sheridan* Fergus Doyle*
Environmental Protection Agency, Ireland	Larry Kavanagh* Gerry Carty, Waste Management Division Manager*

European Foundation, Design for Sustainable Development and SPD Research Programme	Dr. Hans van Weenen*, Director John Hurley Henrik Litske*, Research Manager
Department of the Environment, Transport and the Regions, UK	Bob Ryder, Head of Environment, Business & Consumer Division
Department of Trade and Industry, UK Eco-Efficiency Initiative	Micheal Massey
Envirowise, UK	Dr. Stuart Ballinger*
Forum for the Future, UK	Sarah Parkin
UNEP – WG – SPD (desolved since 2000) & IDEA Consultancy, Amsterdam	Dr. Hans van Weenen
BSI, SIGMA project on sustainability management guidelines	Mark Watson*
National Standards Authority of Ireland	Patrick Breen*, Vincent Delaney*
Design Council, Sustainable Futures Programme, UK	Hannah Curtis*
Environmental Supply Chain Forum, UK The University of Manchester	Barbara Morton
Centre for Sustainable Production & Consumption	Gry Dahl, Consultant
UNEP- TIE, sustainable consumption and cleaner production	Anne Solgaard*
Environment Agency, UK (eLCA project)	Terry Coleman*, Waste Strategy Manager Bernie Thomas
DTI, UK (eLCA project)	Steven Andrews, Sustainable Development Directorate*
European Information, Consumer Electronics and Communications Technology Industry Association (EICTA) EITCA Supply Chain Management Initiative, UK EITCA (Ireland)	Graham Adams, Chair & Environmental Product Design Manager, Motorola (since 2002 at Altran Technologies)* Phil Tyson, Chair & Manager, Marconi John Hayes, Chair ICT Ireland and DfE manager, Hewlett Packard*
BSI, UK	Mark Barthel Head , Sustainability Group Anna Simonsson*
UK Advisory Committee for Consumer Products and the Environment (ACCPE)	"
SETAC, Life Cycle Systems Group of the EPFL	Gerald Rebitzer
Ministry of Housing, Spatial Planning and the Environment, Directorate General for Environmental Protection , The Netherlands and Member of EU IPP informal network	Henny van Rij
Ministry of the Environment, Sweden and Member of EU IPP informal network	Gunilla Blomqvist*

DATA TYPE 4: ESP COMPANIES

	SECTOR	SIZE (large or SME)	Supply Chain Role	CONTACTS (role)
	Plastics	SME	OEM	Technical Director*
	Electronics	"	Tier 1 supplier	Environment Manager*
	Electronics	"	OEM	Manager *
	Packaging	"	OEM	Managing Director (MD) Operations Manager*
	Construction	"	Tier 1 supplier	MD*
	Furniture	"	OEM	MD*
	Timber	"	OEM	Environmental Engineer*
	Plastics	"	Tier 1 supplier	MD*
	Chemical	"	OEM	Vice President Europe (VP)*
	Chemical	"	Tier 1 supplier	MD*
	Engineering	"	OEM	Technical Director*
	Construction	"	OEM	MD*
	Furniture	"	OEM	MD*
	Timber	"	Tier 1 supplier	Project Engineer* MD
	Packaging	"	Tier 1 supplier	MD*
	Consumer Products	"	OEM	MD*

APPENDIX 3: QUESTIONNAIRES

This appendix includes the research questionnaires:

I Questionnaire for Companies
II Questionnaire for Interview/Email Survey

I QUESTIONNAIRE FOR COMPANIES

Aims: To identify information on the following:-

- Industry focused implementation approaches for developing sustainable products and services
- Specific industry drivers and requirements for SPSD approaches (Only question in the case of Data Type 4)
- Factors necessary for effective SPSD implementation
- Implementation approaches used relevant to developing sustainable products and/or services (only for companies with experience in implementing such approaches)

1. COMPANY DESCRIPTION

- Company Size
- Incorporation of sustainability in the company strategy and activities?
- EMS?
    - EMS Type (ISO14001, EMAS, non accredited)
- Product (s) manufactured
- Services provided
- Customers
- Role in supply chain
- Permission to reference company as a contributor to research project
- Permission to use data

2. DRIVERS AND REQUIREMENTS

What are your specific industry drivers and requirements for developing sustainable products and/or services and implementing approaches for SPSD? **(only question in the case of Data Type 4)**

3. DESCRIBE EXPERIENCE OF COMPANY RE SPSD TYPE APPROACH

3.1 APPROACH

Integrated into corporate strategy?

Integrated into Sustainability Management System/EMS?

Integrated into QMS?

Integrated into product conception, design and development processes?

Flexible, customised approach?

Time/resource requirements?

Time from product conception to market?

Company team: conception – development?

- Multidisciplinary
- Understanding of non environmental team members
- Financial, designers, operations, marketing etc…

3.2 PROCESS FOR IMPROVING SUSTAINABILITY OF PRODUCTS AND/OR SERVICES

Integration of TBL with traditional product / service criteria?

- Economic
- Environmental
- Social

Which is the priority weighting if relevant?

- Compliance (e.g. WEEE/ROSH/ELV/Packaging etc.)
- Cost
- Availability
- Customer requirements
- Market demand
- Technical feasibility

Is sustainability/environment now included as standard product criteria?

Life cycle thinking vs. Life Cycle Assessment (LCA)?

- Time required?
- Availability of data for LCA?
- Value of end result?

Do requirements of customer for product information force requirement for LCA?

Qualitative and/or quantitative approaches used?

3.4 CRITERIA CONSIDERED

Functionality & options for PSS?

Wider systems interactions?

Environmental impacts – what is considered?

- Raw materials
- Production
- Distribution
- Consumption
- End of Life (options for recovery for reuse, energy generation, recycling, treatment and disposal)

Reducing social impacts – what is considered?

Other criteria considered?

- Quality
- Technical feasibility
- Cost
- Customer requirements
- Legal/standards requirements

3.5 SUPPLY CHAIN INTERACTION

Effectiveness of working with supply chain players as a team?

- Customers
- Suppliers

What was the view of customer re your offering sustainability improvements?

Was sustainability improvement seen as a requirement by customer?

What are the pros/cons?

3.6 COMMUNICATIONS/LANGUAGE

What do you call your SPSD type approach?

- SPD, EPD, Ecodesign, Design for Environment

Are "sustainability/environment" and other SPD terminology used?

- Sustainability related personnel
- non Sustainability related personnel

What is the aim of the approach communicated as?

- to meet specified criteria
- need to highlight sustainability

3.7 SUPPORT TOOLS

What support tools were used?

- Qualitative and Quantitative
- Checklists
- LCA software
- Other software tools
- Matrices etc.

Media preferred?

- Web based
- Intranet based
- Connection with supplier/customer

4.0 FACTORS NECESSARY FOR EFFECTIVE SPSD IMPLEMENTATION

What factors do you think are necessary for effectively implementing SPSD in manufacturing industry?

II QUESTIONNARE (for interview/email survey)

INTRODUCTION

This questionnaire is to obtain your views on Sustainable Product and Service Development (SPSD) implementation approaches for manufacturing industry.

Sustainable Product & Service Development (SPSD)* in manufacturing industry is defined as the process of integrating sustainability criteria with traditional product and service criteria over the entire product lifecycle (conception to end of life) to develop products and/or services which meet a required functionality, are economically efficient, ecologically sound, and socially acceptable.

PLEASE ANSWER THE FOLLOWING QUESTIONS:-

1. **Are you aware of any existing guides for implementing SPSD in manufacturing industry? (excluding guides on Environmental Product Development approaches e.g. ecodesign, Life Cycle Assessment etc...)?**

Yes ☐ No ☐

If yes, please provide brief details:-

2(a) What factors do you think are necessary for effectively implementing SPSD in manufacturing industry?

(Effective SPSD implementation in manufacturing industry is intended to result in the development of more sustainable products and/or services as well as meeting manufacturing industry requirements.)

2(b) Specifically, what do you think manufacturing industry's requirements are regarding SPSD approaches?

2. Factors important for effectively implementing SPSD in manufacturing industry highlighted by the research to date* are as follows. Tick those you agree with and rank those chosen in order of importance (1 = most important, 2 = less important etc...) ***[In Email Survey Only]***

☐ Rank
Incorporating a commitment to SPSD into the corporate strategy and from there into all business systems to include sustainability / environmental management and product development systems.

☐ Rank
Simple, flexible, qualitative approach backed up by quantitative tools as required.

☐ Rank
Changing the manufacturers' mindset from the provision of products to the provision of functions.

☐ Rank
Considering all options for providing the required functionality, to include whether it can be provided by a service, product or some combination of a Product Service System.

☐ Rank
Integration and optimisation of all triple bottom line criteria (social, environmental and economic) with other traditional product and/or service criteria throughout the product and/or service development process.

☐ Rank
Targeting SPSD implementation at companies with control of the product and/or service conception, design and development lifecycle stages.

☐ Rank
Use of business language suited to the company/industry sector culture.

3. Please note any additional comments below.

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE. YOUR INPUT IS GREATLY APPRECIATED.

Dorothy Maxwell, Environmental Policy and Management Group (EPMG), Imperial College, London
dorothymaxwell@eircom.net

* Maxwell and van der Vorst (2003), Developing Sustainable Products and Services, Journal of Cleaner Production, Volume 11, Issue 8, December 2003, pp. 883 - 895, Received 5/09/02; Accepted 27/10/02, Elsevier Science Ltd.

APPENDIX 4: EXISTING ENVIRONMENTAL PRODUCT DEVELOPMENT (EPD) METHODS AND TOOLS

1.0 EPD STRATEGY AND IMPLEMENTATION EXAMPLES

Examples of the tools in **Chapter 4, Table 4.3** are summarised below.

The *Promise Manual* developed by Delft University of Technology (Brezet and van Hemel, 1997) is a comprehensive guide to improving the environmental profile of a product system throughout its lifecycle. The Promise approach is a definitive ecodesign guide including background information, a seven step ecodesign implementation process with associated work sheets, case examples, information on support tools e.g. LCA and related topics e.g. green marketing. The seven step ecodesign implementation approach aims at integrating ecodesign into product development and includes the following steps:-

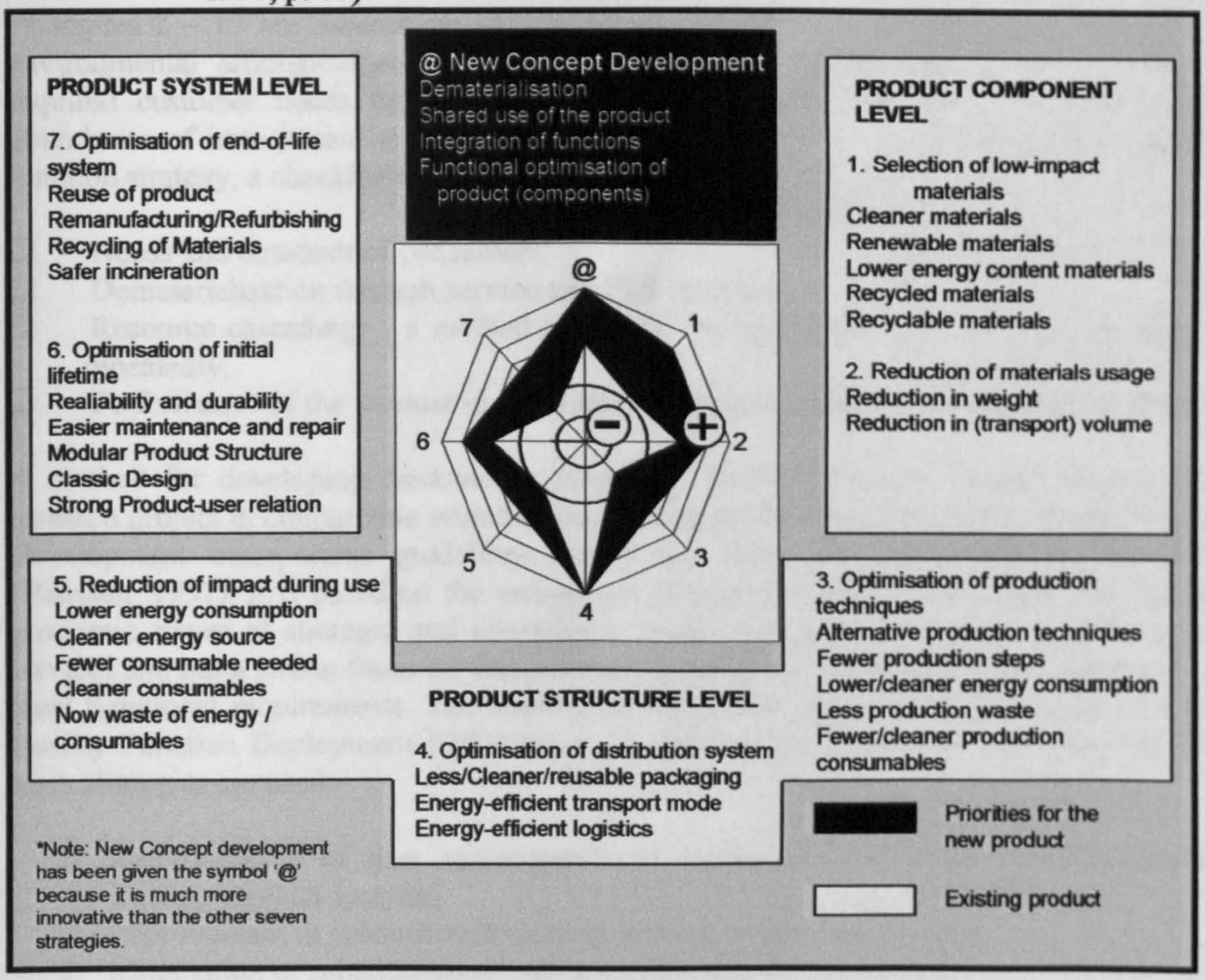
1. Organising an ecodesign project
2. Selecting a product
3. Establishing the ecodesign strategy
4. Generating and selecting product ideas
5. Detailing the concept
6. Communicating and launching the product
7. Establishing follow up activities.

Qualitative and quantitative tools for assessing the environmental product profile e.g. the MET Matrix and LCA are included. The MET Matrix provides a qualitative matrix to assess and prioritise material, energy and toxic emissions related impacts at different lifecycle stages. An Ecodesign Checklist of issues to be considered at each lifecycle stage (from product conception through to recovery and disposal) to develop environmental improvement options is provided. The identified strategies for ecodesign are visualised using the *Ecodesign Strategy Wheel (ESW)*. The ESW uses 8 life cycle categories to be assessed in developing an eco-design strategy as follows:-

- New Concept Development (questioning the requirement for a product)
- Selection of low impact materials
- Reduction of materials usage
- Optimisation of production techniques
- Optimisation of distribution system
- Reduction of impact during use
- Optimisation of initial lifetime
- Optimisation of end of life system.

The ESW is illustrated in **Figure A4.1**. This is used to illustrate eco design objectives and provide a basis for analysis and illustration of environmental improvement options.

Figure A4.1 Ecodesign Strategy Wheel (ESW) (Source: reproduced from Brezet et al, 1997, p. 81)



The *Life Cycle Design (LCD)* Manual developed by a collaboration of European partners in an European Commission project (Behrendt et al, 1997) provides background information, guidelines for implementing Life Cycle Design and case examples for reducing the environmental impact of product systems. The LCD Checklist is a series of checklists with specific criteria under consideration for the following thirteen environmental principles:-

1. Achieving environmental efficiency/optimal function
2. Saving resources
3. Use of renewable and sufficiently available resources
4. Increasing product durability
5. Design for product reuse
6. Design for material recycling
7. Design for disassembly
8. Minimising harmful substances
9. Environmentally friendly production
10. Minimising environmental impact of product in use
11. Using environmentally friendly packaging
12. Environmentally friendly disposal of non-recyclable materials

13. Implementing environmentally friendly logistics

Principles 2 – 13 are focused on environmental optimisation. Principle one "Achieving environmental efficiency/optimal function" focuses on finding new ways to meet the required customer needs by questioning the functionality required and stretching the boundaries of how it can be provided (Behrendt et al, 1997, p. 54). Under this optimal function strategy, a checklist of issues is considered to include:-

- Needs and demands of consumers;
- Dematerialisation through service and PSS options;
- Resource cascading - a method to extend the useful life of a resource by using it repeatedly;
- Performance of the product in the wider system it operates in (Behrendt et al, 1997).

A method for developing *Sustainable Industrial Product Systems* created as part of a research project in conjunction with the Nordic Project for Environmentally Sound Product Development incorporates guidelines, associated tools and case examples for EPD (Hanssen, 1997). It is based on the integration of environmental performance, quality and economic issues at strategic and operational levels in the development of products and services and has a strong focus on determining the most environmentally sustainable way to meet functional requirements. The method includes LCA, Life Cycle Costing (LCC) and Quality Function Deployment (QfD) tools. To achieve environmental improvements four main strategies are used:-

1. Reformulation of user requirements to determine innovative solutions beyond existing product systems
2. Improvement in product performance regarding user requirements
3. Elimination or substitution of whole or parts of product systems
4. Environmental optimization across the product system lifecycle and value chain (Hanssen, 1999).

The *Ecodesign Navigator*, developed as a result of the Design for Environment Decision Support (DEEDS) research project at Manchester Metropolitan and Cranfield Universities, UK (Simon et al, 1998), provides an ecodesign implementation approach for integrating ecodesign in product development incorporating strategy formulation, a comprehensive toolbox and support information (Simon et al, 1998). A cradle to grave lifecycle thinking approach is utilised.

The *RMIT Guide to EcoReDesign*™ (Gertzakis et al, 1997) and more recent *Design + Environment: A Global Guide to Designing Greener Goods* (Lewis et al, 2001) were developed at the Centre for Design, Royal Melbourne Institute of Technology (RMIT), Australia. Both provide background information, ecodesign guidelines, implementation approach, checklists and case examples for EPD with the main focus on redesigning existing products to reduce their environmental impact over a product lifecycle consisting of raw materials to end of life. The *Guide to EcoReDesign*™ is based on EcoReDesign demonstration schemes run by the Centre for Design at RMIT with companies in Australia since 1993 (the most recent phases focusing on SMEs) (Gertzakis et al, 1997).

Four steps are covered in the EcoReDesign implementation process as follows:-

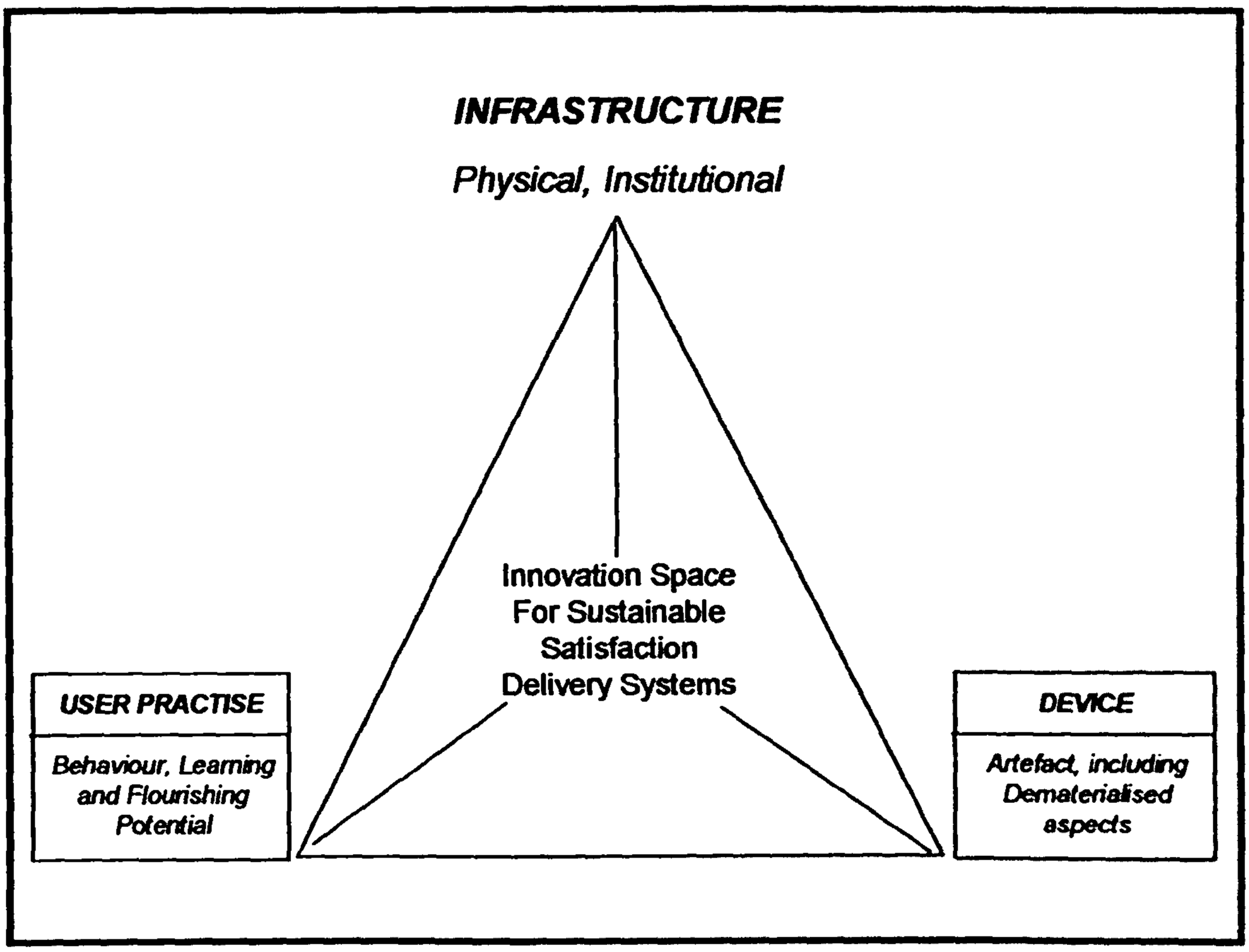
- Phase 1 selection of the product;
- Phase 2 Analysis of the environmental impact and establishing design directions;
- Phase 3 Realisation of a design (or redesign) which reduces or eliminates key environmental impacts;
- Phase 4 Production and marketing of the redesigned product (Gertzakis et al, 1997).

Philips Electronics have published *Point of No Return Ecodesign Guidelines* (Philips, 1997) and *Greening Your Business* (Philips, 2000) for use by other organisations. *Point of No Return* provides ecodesign guidelines within the structure of an EMS to ISO14001 in line with the Philips POEM approach (Meinders, 1999). Greening Your Business is a follow up providing strategic and operational guidelines and tools for improving environmental performance with a specific focus on ecodesign.

Design of Eco-Efficient Services developed by Delft University in conjunction with TNO and the Dutch Ministry for Environmental Affairs (Brezet et al, 2001) is a method and toolkit aimed at developing systems of products and services called "Sustainable Satisfaction Delivery Systems" (Brezet et al, 2001, p. 25), which cause minimal environmental impact with a maximum added value. It is seen as an update to the PROMISE Manual and an extension of that EPD implementation method. The Design of Eco-Efficient Services method reflects the increasing recognition of a role for eco efficient services in the sustainable provision of functions rather than via physical products. It provides an implementation approach, toolbox and case examples for product and service based organisations with the aim of providing "functions with minimal environmental impact, use of resources and use of space, while creating maximum added value for the different stakeholders" (Brezet et al, 2001, p. 6). A Sustainable Systems Triangle (see **Figure A4.2**) illustrates the framework for designing sustainable satisfaction delivery systems. This framework proposes that the key to a more sustainable result is for designers to look in a holistic and integrative manner for the innovative potential of the following three aspects :-

- The device/artifact (i.e. innovations to improve the eco-efficiency of the process, product or service);
- The physical and institutional context/infrastructure (innovation in infrastructure/institutions related to using the products and services e.g. leasing instead of purchase and ownership or the new infrastructure required for hydrogen fuelled cars);
- User practice (innovation in user behaviour e.g. a consumer learning to drive and fuel a hydrogen fuelled car).

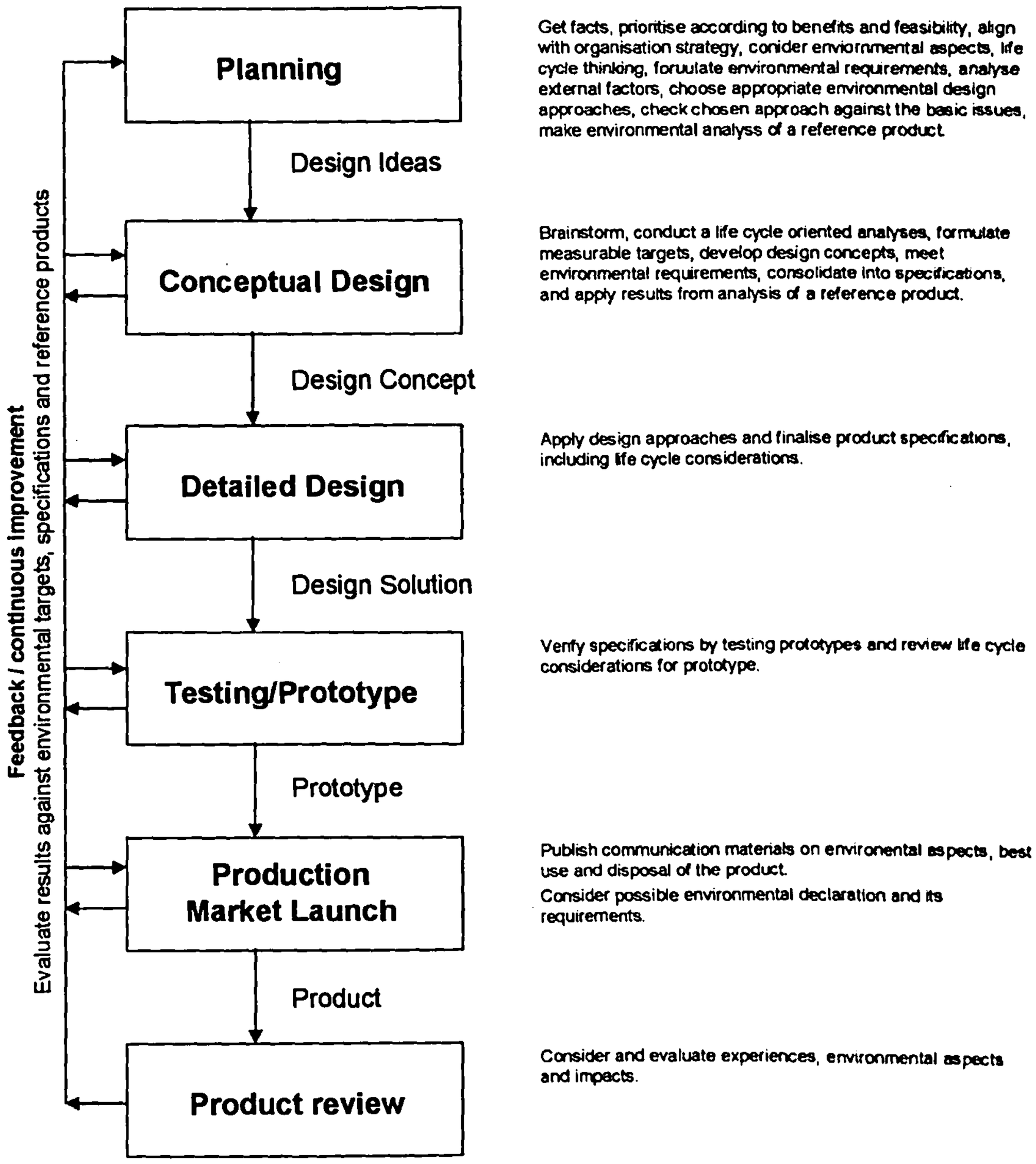
Figure A4.2 Sustainable Systems Triangle (SST) (Source: reproduced from Brezet et al, 2001, p. 28)



Also developed at Delft University, the *Product Innovation for Cleaner Production (PI4CP)* approach is focused on product improvement, process improvement, function/service improvement and improvement of commercial cooperation, subcontracting and supply-chain aspects (Diehl and Crul, 2002).

ISO Guide 64 provides a guide for ecodesign which has largely been superseded by *ISO /TR 14062 Integration of Environmental Aspects into Product Design and Development* (ISO, 2002a). ISO14062 provides a guide for incorporating environment into the design and development of products and services with the aim of reducing adverse environmental impacts throughout the entire lifecycle. It is for use by those involved in product design and development. The guide incorporates strategic (including organisation and communication), management (including integration with existing management systems, use of multidisciplinary approach, information and data management and supply chain management) and product considerations (including mainstream ecodesign strategies to reduce environmental impact). The standard defines the stages of product design and development and how environment can be integrated into this is illustrated in **Figure A4.3**.

Figure A4.3 Example of a generic model of integration environmental aspects into the product design and development process (Source: reproduced from ISO14062, p. 15 (ISO, 2002a)



In the Planning phase, the functionality of the product is considered. This includes considering the functionality, as distinct from just providing a specific technical solution. The functionality is described as *"how well the product suits the purpose for which it is intended in terms of usability, useful lifetime, appearance etc."* (ISO, 2002a, p. 10). Using a broad approach in determining the options to meet the *"functionality required to fulfil customer or user demands and needs"* is advocated to include consideration of services and PSS combinations ((ISO, 2002a, p. 10). The environmental aspects and impacts associated with the product and/or services function is also determined in the Planning phase. Conceptual design uses the information from the Planning stage to realise design options and iteratively evaluate them. In Detailed Design the concepts are developed further and subsequently tested in the Testing/Prototype phase against the required environmental and other specifications. Guidance on marketing and communicating environmental aspects are specified in the Market Launch stage. Finally, a Product Review stage is advocated to assess feedback from stakeholders on whether the environmental expectations have been met and to incorporate these back into the planning process as relevant. Overall, the standard is based on an iterative continual improvement in product design and development using a Plan, Do, Check Act management systems approach (ISO, 2002a).

The standard includes the use of a life cycle approach to identify environmental aspects and impacts over the entire lifecycle. The product life cycle stages are defined as five steps from raw material acquisition to end of life (ISO, 2002a). Suggestions for tools to support the stages of the process are also specified.

A range of sectorally focused EPD methods and tools have been developed for the automotive and electronics sectors Examples of these sectorally focused EPD methods include the following:-

- *Eco Design Guide: Environmentally Improved Product Design Case Studies of the European Electrical and Electronics Industry* developed by the European Commission ECOLIFE Thematic Network[2] (ECOLIFE, 2002)
- *Ecodesign - the Electrical and Electronic Practical Eco-design Guide*, developed at theUniversity Rovira i Virgili, Spain in conjunction with UNEP (Rodrigo and Castells, 2002)
- *CfSD Eco-Design Checklists* developed by the Centre for Sustainable Design (CfSD), University of Surrey, UK (Clark and Charter, 1999)
- *Standard ECMA - 341*, "Environmental design considerations for electronic products", (ECMA International, 2002).

These include an ecodesign implementation approach, strategies, and associated information on concepts and tools e.g. LCA customised to the electronics sector. The ecodesign implementation approaches are based on environmental optimisation across the product and service lifecycle and value chain to incorporate interaction with the supply chain. The first two guides also incorporate electronics case examples. The *CfSD Eco-*

[2] The ECOLIFE Network consists of 28 partners including producers, SMEs, recyclers, research, academic and scientific institutions from 10 European Countries.

Design Checklists provide a tool for identifying the life cycle environmental, engineering, market etc. issues. This information is assessed to highlight the most suitable areas for product improvement. Part of this checklist is a one page *Eco-design Healthcheck* questionnaire designed to provide a quick assessment of a companies eco-design performance on a rating from 1 – 5 (poor to excellent). Standard ECMA-341 provides requirements, recommendations and a checklist for the design of commercially viable, environmentally conscious information and communication technology and consumer electronics products. It focuses on energy and resource consumption, materials selection, extending product life and end of life environmental issues (ECMA International, 2002).

2.0 ASSESSMENT AND DECISION SUPPORT LCI/LCA EXAMPLES

Examples of LCI, LCA and abridged LCA tools are in **Table A4.1.**

Table A4.1 Examples of LCI, LCA and abridged LCA tools

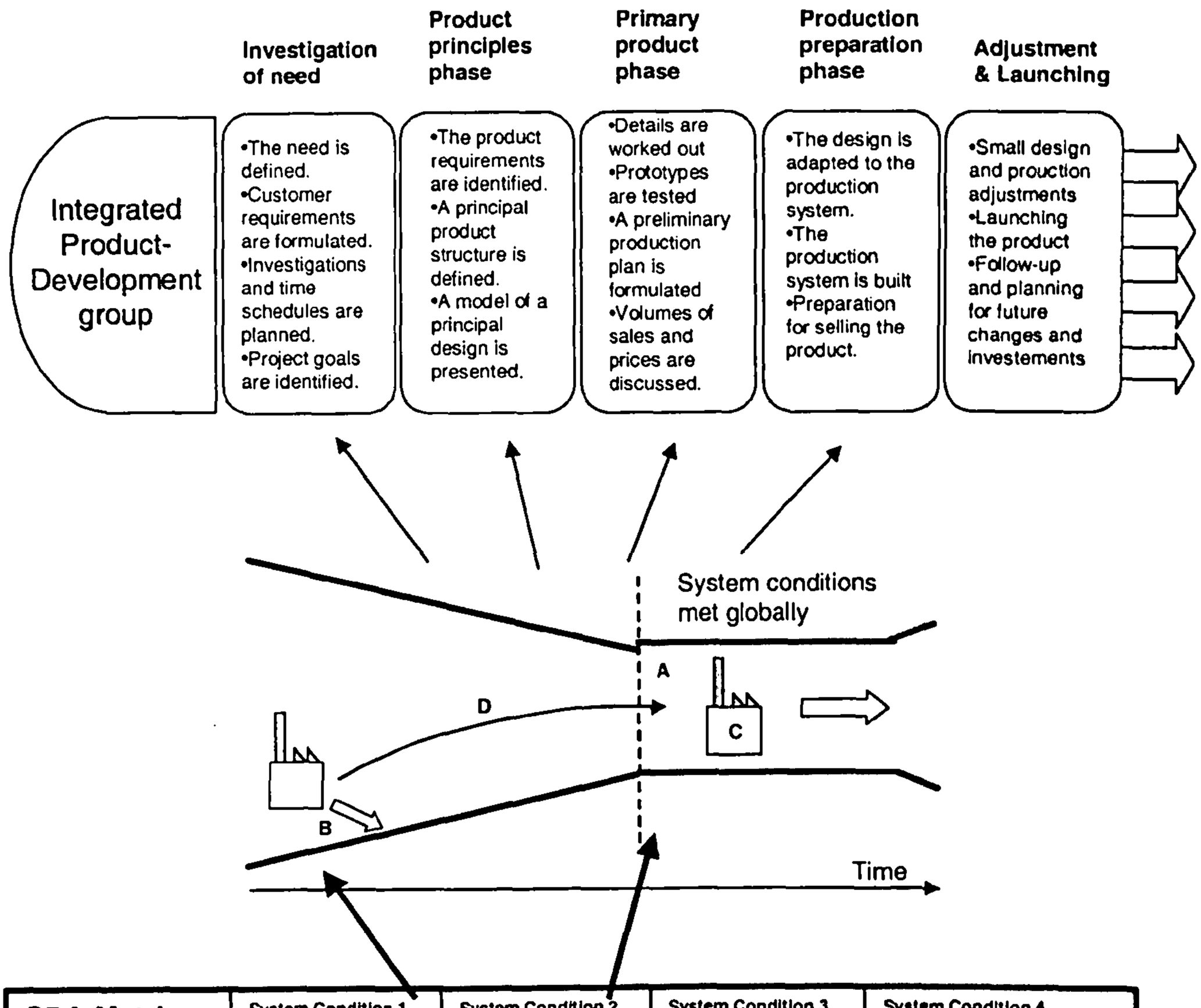
LCI	Full LCA	Abridged LCA
Boustead Model (UK)	Simapro (The Netherlands	Eco-Indicator'95 & '99 (The Netherlands)
LCAiT (Sweden)	PEMS(used in UK)	Ecoscan 2.0 (The Netherlands)
Euklid (in line with ISO14040/41) (Germany)	TEAM (used in UK)	MET Matrices Method
	Umberto (Germany)	ECOPACK2001 (for packaging sector)
	EDIP LCV (Denmark)	Ecopro 1.4 (for packaging sector) (Switzerland)
	GaBi 4 (Germany)	Workbench LCA tool (Ireland)

APPENDIX 5: SUSTAINABLE PRODUCT DEVELOPMENT (SPD) APPROACHES

1.0 METHOD FOR SUSTAINABLE PRODUCT DEVELOPMENT (MSPD)

The Method for Sustainable Product Development (MSPD) is being developed at *Chalmers University of Technology & Gothenburg University* in Sweden (Byggeth et al, 2000; Byggeth & Broman , 2000). The MSPD is a method for SPD in companies with particular application to SMEs and is being developed in conjunction with ten Swedish SMEs. **Figure A5.1** illustrates MSPD which consists of three tools, an Integrated Product Development Model (IPDM), ABCD tool and SPA-matrix.

Figure A5.1 MSPD – consisting of three tools, an integrated product development model, the ABCD-tool and the SPA-Matrix. For each product development phase an ABCD-analysis is performed and a SPA is used in the B-and C step.
(Source: reproduced from Byggeth et al, 2000, p. 7)



SPA-Matrix	System Condition 1 For society to be sustainable the eco-system must not be systematically....	System Condition 2 For society to be sustainable the eco-system must not be systematically....	System Condition 3 For society to be sustainable the eco-system must not be systematically....	System Condition 4 For society to be sustainable resources must be used efficiently and fairly to meet basic human ....
Inflow	Hierarchichally ordered questions based on system condition 1 and inflow to products and/or processes	Hierarchichally ordered questions based on system condition 2 and inflow to products and/or processes	Hierarchichally ordered questions based on system condition 3 and inflow to products and/or processes	Hierarchichally ordered questions based on system condition 4 and inflow to products and/or processes
Production Process	Hierarchichally ordered questions based on system condition 1 & 2 and the production processes		Hierarchichally ordered questions based on system condition 3 and production processes	Hierarchichally ordered questions based on system condition 4 and production processes
Outflow	Hierarchichally ordered questions based on system condition 1 and outflow through the product	Hierarchichally ordered questions based on system condition 2 and outflow through the product	Hierarchichally ordered questions based on system condition 3 and outflow through the product	Hierarchichally ordered questions based on system condition 4 and outflow through the product
Communica-tion	Hierarchichally ordered questions based on the four system conditions and communication with actors such as subcontractors, politicians and customers.			

The MSPD applies SPD within an Integrated Product Development Model (IPDM) already used for product design and incorporates existing product design methods e.g. Concurrent Engineering (CE). The MSPD incorporates all phases of product development starting with determining the need for a product, through to launching the product. Superimposed on this is a backcasting process for sustainability based on The Natural Step (TNS). In this analysis, the criteria for sustainability using the TNS four system conditions for Sustainable Development as follows are determined.

"For society to be sustainable, the ecosphere must not be systematically subject to:-

1. *Increasing concentrations of substances from the lithosphere;*
2. *Increasing concentrations of substances produced by society;*
3. *impoverishing physical manipulation or over-harvesting, and*
4. *Resources must be used efficiently and fairly to meet basic human needs worldwide"* (Byggeth et al, 2000).

The present product situation is then analysed against these criteria and future strategies for making the product sustainable are determined. In determining these future strategies, issues such as technical feasibility, market requirements and economic feasibility are included to prevent unrealistic strategies being determined. The analysis is conducted using a SPA-matrix of structured questions based on the sustainability criteria which are asked for each life cycle phase of the product. The matrix is built up from the questions and answers and functions mainly as a way of structuring the information. The results from answering the questions are then used as a guide of possible ways to make the product sustainable. This analysis is done at each phase of the product development process in order to fully incorporate sustainability at each stage.

While the MSPD aims to include social aspects of sustainability based on the TNS four system conditions, these were identified as limited in terms of the social criteria advocated in the existing guidance as discussed already in Chapter 4, 4.2.4. Hence the true TBL focus of MSPD is limited in terms of the extent of social impacts considered in the development of sustainable products and services. Work is currently underway to incorporate social criteria from existing social approaches into The Natural Step approach itself in order to explicitly include social aspects of sustainability (Waage et al., 2004; TNS, 2004).

2.0 CYCLIC/SOLAR/SAFE

"Cyclic/Solar/Safe" is a philosophy for understanding products and how they can be more sustainably developed by Edwin Datschefski of *BioThinking International* and *Greener by Design* (Datschefski, 2000). The overall concept is that products should be compatible with nature. Products and industrial products should be completely cyclic, solar, safe, eco-efficient and socially just.

Datchefski proposes five design requirements for sustainable products as follows in **Box A5.1**.

Box A 5.1 Five design requirements for sustainable products

The first three mimic the protocols used by plant and animal ecosystems:-

Cyclic: The product is made from organic materials, and is recyclable or compostable, or is made from minerals that are continuously cycled in a closed loop.

Solar: The product uses solar energy or other forms of renewable energy that are cyclic and safe, both during use and manufacture.

Safe: The product is non-toxic in use and disposal, and its manufacture does not involve toxic releases or the disruption of ecosystems.

The fourth requirement is based on the need to maximise the utility of resources in a finite world:

Efficient: The product's efficiency in manufacture and use is improved by a factor of ten, requiring 90% less materials, energy and water than products providing equivalent utility did in 1990.

And the fifth requirement recognises that all companies have an impact on the people who work for them and the communities within which they operate:

Social: The product and its components and raw materials are manufactured under fair and just operating conditions for the workers involved and the local communities.

3.0 MBDC SUSTAINABLE DESIGN PROTOCOL & CRADLE TO CRADLE DESIGN™

MBDC Sustainable Design Protocol & Cradle to Cradle Design™ were developed by William McDonough and Michael Braungart of *McDonough Braungart Design Chemistry* (MBDC). MBDC propose this approach as a design paradigm moving away from the cradle to grave lifecycle model of the last century to a cradle to cradle lifecycle approach for designing processes, products and services of the *"next industrial revolution"* which are based on natural cycles (McDonough and Braungart, 2002, p. 6). This approach moves beyond eco-efficiency (seen as being based within the same system that has caused sustainability problems and seeks to slow down through restriction but not stop these problems) to use Eco-effectiveness. MBDC see an eco-effective strategy as departing from the conventional concepts of eco efficiency and sustainability which they see as based on limitation, to an approach based on abundance, creativity and prosperity. Eco-efficiency is seen as trying to be less bad whereas eco-effectiveness *"begins by imaging what 100% good might look like and charts progress towards that goal"* (McDonough and Braungart, 2002, p.6). Some definitions of these

concepts proposed as necessary for the next industrial revolution are outlined in **Box A5.2**.

Box A5.2 MBDC Concepts for the Next Industrial Revolution

"**Cradle to Cradle Design** is a new strategy for business growth and prosperity that generates ecological, social, and economic value. It represents a fundamental conceptual shift away from the flawed system design of the Industrial Revolution, not just a damage management strategy"(MBDC, 2002).

"**Eco-effectiveness** has profound implications for industries everywhere. Rather than lamenting a world of hazardous waste, scarce resources, and limited opportunities, it celebrates an abundance of continuously valuable industrial and natural materials, of rich and diverse living systems, of economic and environmental wealth" (MBDC, 2002).

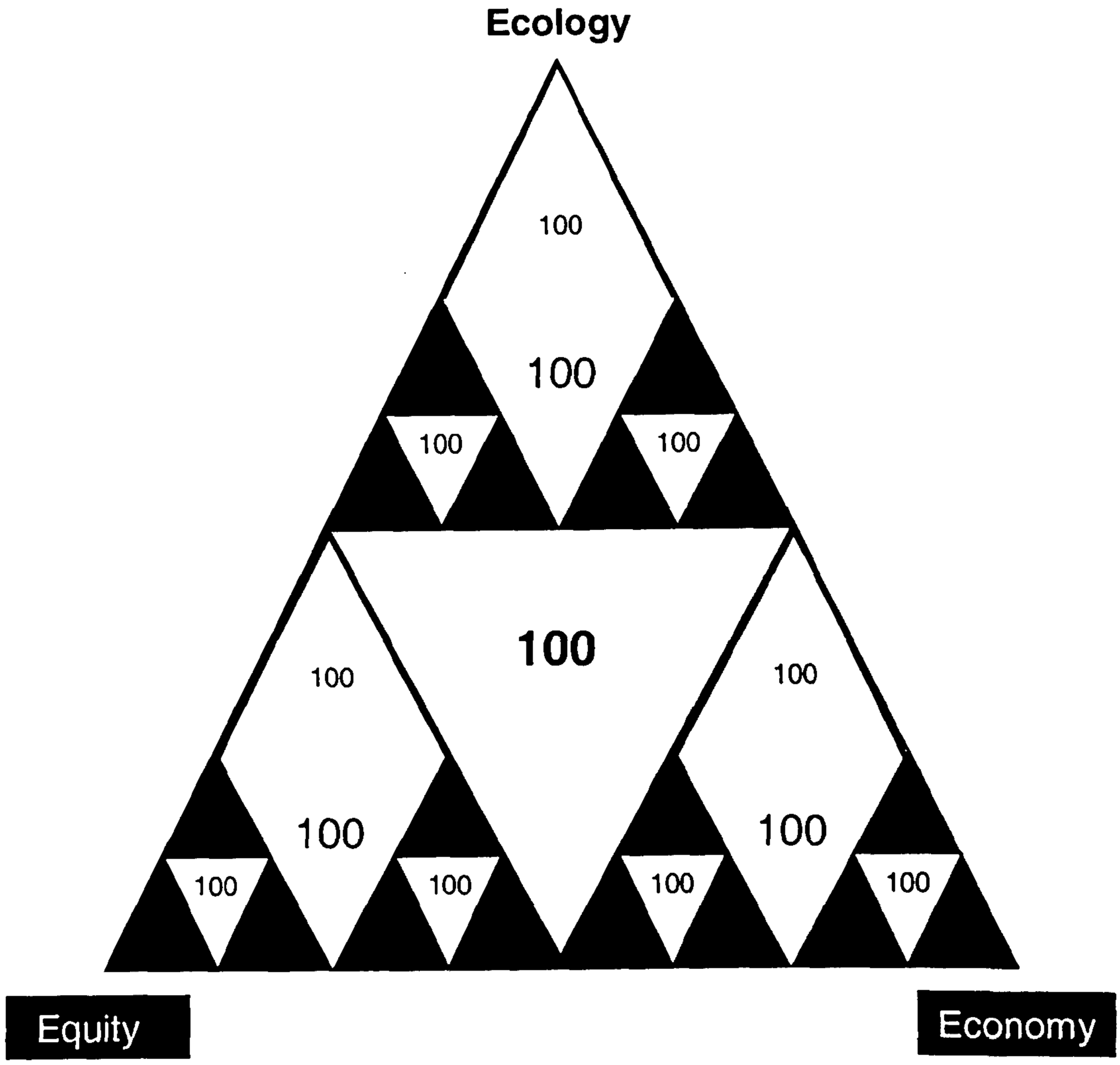
MBDC define a five step strategy for eco-effective design to:-

> *"define, select and ultimately reinvent product ingredients, industrial systems and even the relationship between producers and consumers. Its intention is nothing less than the transformation of human industry; it seeks a world in which the production and consumption of goods is not only safe and profitable but ecologically enriching and socially valuable"* (Braungart, 2002, p. 1).

These five steps are a gradual process of comprehensively examining a product to incorporate the determination of how best the product or service can *"celebrate a human need, revitalise an aspect or culture, renew engagement with nature"* and be *"ecologically intelligent"* (Braungart, 2002, p. 2). The aim is not to limit the impact of a product or service but conceive one with *"positive effects on the world"* (Braungart, 2002, p. 1). This approach sees products as *"packaging for services"* and applies the strategy to *"products of service"* to determine the most effective way to meet a human need (Braungart, 2002, p. 1). Customers buying a service rather than purchasing a product is a key feature of this approach.

In terms of the incorporation of TBL sustainability, MBDC define a Fractal ecology model for a sustainable design as illustrated in **figure A5.2**. The model proposes that designers of industrial processes, products and services should aim to optimise equity (social justice), economy (market viability) and ecology (environmental intelligence) (McDonough and Braungart, 2002).

Figure A5.2 MBDC Fractal ecology model (Source: reproduced from McDonough and Braungart, 2000)



MBDC specify the following fundamental design principles:-

- ❑ Waste equals food;
- ❑ Use of solar income;
- ❑ Respect Diversity.

Waste equals food is about creating products actively defined as nutrients for either of two district metabolisms of Earth – *"Biological cycles"* (cycles of nature) and *"Technical Cycles"* (cycles of industry). This is illustrated in **Figure A5.3**. A products *"biological nutrients"* and *"technical nutrients"* flow in one or the other of these closed loops, cradle to cradle cycles providing *"nourishment"* for something new after each life (McDonough and Braungart, 2002, p. 105, 109). Isolating technical nutrients from biological enables them to be upcycled rather than downcycled by recycling. This

enables the value of the technical nutrients to be retained for industry and a reduced environmental impact from upcycling as distinct from downcycling (McDonough and Braungart, 2002). *"Products of consumption"* (McDonough and Braungart, 2002, p. 105) (e.g. biodegradable packaging) are consumed in the biological cycle and should return to the soil safely. *"Products of service"* (McDonough and Braungart, 2002, p. 111) (e.g. electronics goods) circulate in the technical cycle feeding back into industry for reuse.

"Use of solar income" relates to the use of solar energy as distinct from reliance on fossil fuels. "Respect Diversity" relates to respecting and enhancing regional, cultural and material diversity.

Further design criteria are defined as:-

- ❑ Cost
- ❑ Performance
- ❑ Aesthetics
- ❑ Ecological Intelligence
- ❑ Justice
- ❑ Fun.

The first three criteria above are seen as relevant to the first industrial revolution only and augmented by the last three in light of the next industrial revolution.

For Products of Consumption, the MBDC Sustainable Design criteria include an initial *X-Filter™ of Eco-Effective Design Criteria (MBDC*, 2002). If a products components and process pass the X-Filter criteria they are evaluated under the remaining Eco-Effective Design Criteria. The Eco-Effective Design Criteria, to include the X-filter criteria, are illustrated in **Table A5.1**.

Figure A5.3 Biological and Technical Cycles (Source: reproduced from Braungart, 2002)

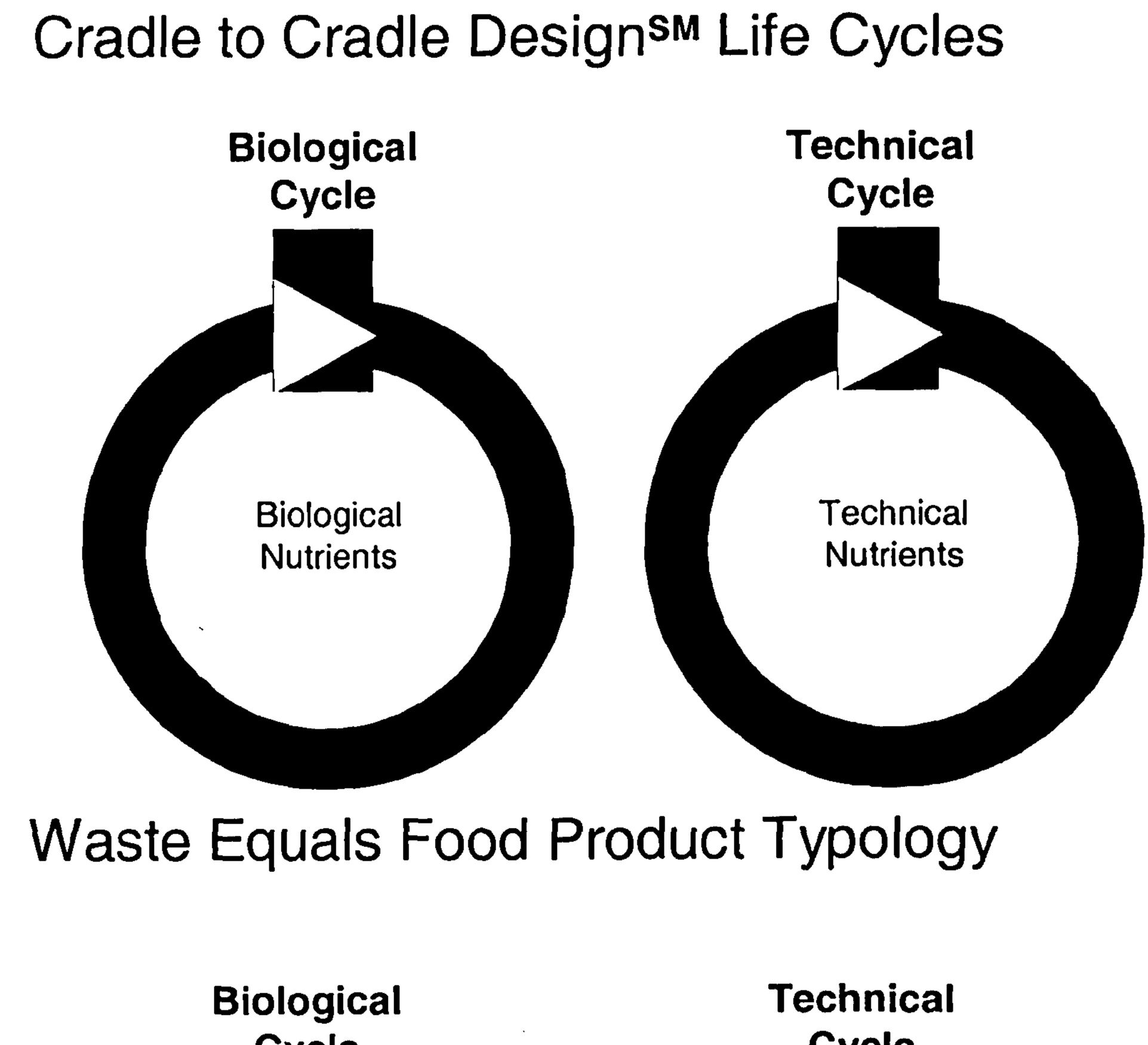


Table A5.1 Eco-Effective Design Criteria (Source: reproduced from MBDC, 2002)

ENVIRONMENTAL RELEVANCE
BIODEGRADATION
METABOLIC PATHWAY
FISH TOXICITY
DAPHNIA TOXICITY
PERSISTANCE
BIOACCUMULATION (LOG POW)
CONTENT OF HALOGENATED ORGANIC COMPOUNDS
BACTERIA TOXICITY
WORM TOXICITY
HEAVY METAL CONTENT
HEALTH HAZARDS
DISRUPTION OF IMMUNE SYSTEM
IRRITATION OF SKIN / MUCOUS MEMBRANES
CHRONIC TOXICITY
ALLERGENICITY
CARRIER FUNCTION
PRODUCTION PROCESS
EXACT KNOWLEDGE OF COMPOSITION
RESOURCES (RENEWABLE / NONRENEWABLE)
TRANSPORT DISTANCE
ENERGY INPUT
SOCIAL CRITERIA
DANGER OF INTERMEDIATES / BY-PRODUCTS
CLIMATIC RELEVANCE / OZONE DEPLETION
WASTES
ANIMAL TESTING
GENETIC ENGINEERING
X-FILTERS™ OF THE ECO-EFFECTIVE DESIGN CRITERIA
CARCINOGENICITY*
TERATOGENICITY*
MUTAGENICITY*
ACUTE TOXICITY AND BIOACCUMULATION / PERSISTENCE
DISRUPTION OF ENDOCRINE SYSTEM*

*Known or suspected in human or animal

Other associated MBDC tools relevant to developing sustainable products and services include the *McDonough Braungart Index of Sustainability* (MBDC, 2002) to evaluate

and track the progress of process and product design toward sustainability and the *Five Dot Optimisation Scale* (MBDC, 2002) representing different grades of ecologically intelligent design based on the five step eco effective design strategy. The scale as illustrated in **Figure A5.4** runs from preferable to fully ecoeffective as the ecological intelligence of the product increases, in particular focusing on human and environmental toxicity.

Figure A5.4 MBDC Five Dot Optimisation Scale (SOURCE: reproduced from MBDC, 2002)

The '**optimized by MBDC**' five-dot optimization scale, based on MBDC's 'five steps to eco-effectiveness,' indicates the following:

● ○ ○ ○ ○
1. "Free of... This is a market-induced product improvement, removing a substance widely perceived as environmentally unfriendly. MBDC does not lend its logo to these products.

● ● ○ ○ ○
2. Preferable. A 'preferable' product is one that exhibits environmental vision and leadership, but without a complete human health and environmental characterization of its material and chemical makeup. A 'preferable' product may still have environmental flaws, but it begins to move toward Cradle to Cradle Design in some significant way.

● ● ● ○ ○
3. Fully Assessed. A 'fully assessed' product has been evaluated using MBDC's Cradle to Cradle Design Protocol for Material and Chemical Assessment. All chemical and material inputs are known, and have been assessed according to the criteria of the Protocol. At a minimum, substances of the greatest concern within the Protocol have been eliminated or replaced with substances of less concern.

● ● ● ● ○
4. Optimized. An 'optimized' product has been fully assessed and, to the extent feasible, optimized for material health and safety according to MBDC's Cradle to Cradle Design Protocol for Material and Chemical Assessment. The product is designed for optimal value recovery within closed-loop systems (true recycling and/or return to the biological metabolism).

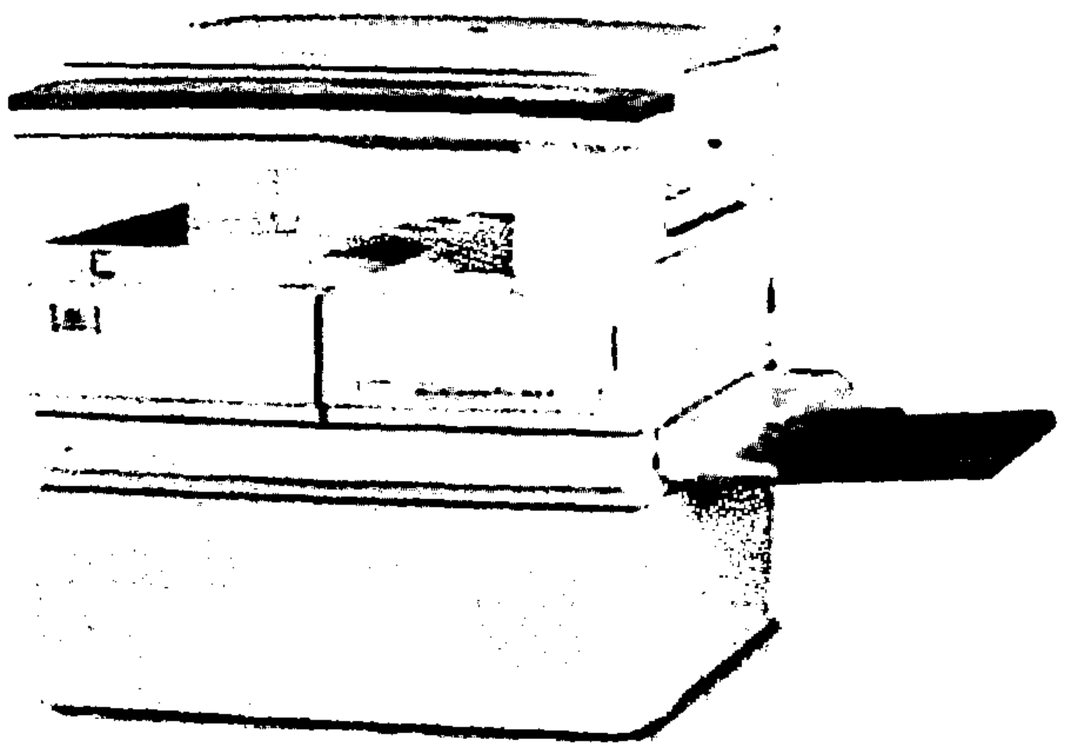
● ● ● ● ●
5. Fully Eco-Effective. In MBDC's optimization scale, a 'fully eco-effective' product is one that incorporates as completely as possible all of the material, process, energy, and other aims of Cradle to Cradle Design, as described by MBDC.

The optimized by MBDC logo indicates MBDC's belief in the ecological intelligence of market-leading products. It is based on the depth of MBDC's research and understanding of each product, and according to the criteria of the company's Protocol and its vision for Cradle to Cradle Design.

Companies working with MBDC using these approach to different extents include *Ford Motor Company, Nike, Rohner Textil, Herman Miller, Design Tex, Victor Innovatex, BASF, Volvo* and *Pendleton* (McDonough and Braungart, 2002). Further discussion on these industry examples is in **Chapter 5.**

APPENDIX 6: DOCUMENTED COMPANY EXAMPLES

1.0 XEROX - "THE DOCUMENT COMPANY"



(Xerox, 2001)

Xerox provides document management services, a PSS. This incorporates the following activities:-

- manufacture of printers, copiers, faxes, scanners and multifunction products for sale and lease;
- manufacture of associated products e.g. paper, cartridges etc.;
- Provision of upgrade, maintenance and repair services;
- Document management consultancy services (Xerox, 2001a).

In terms of their overall environmental strategy, Xerox have integrated environment into their corporate strategy globally. Further environment is integrated into the business strategic planning process as well as the product design & development process (Xerox Corporation, 2001).

The group manufacturing plants operate EMS accredited to ISO14001. In general there are three main corporate environmental aims:-

- Waste free products;
- Waste free factories;
- Waste free workplaces – customers (Xerox, 2001a and 2002; Smith, 1997).

Other characteristics of the general Xerox approach to environmental management are interaction with supply chain companies e.g. suppliers and sub contractors as well as the transfer of environmental knowledge through publications for industry and partnership projects (Ecolife, 2002).

In terms of product design and development, the company call their approach "Sustainable Product Design" (Xerox, 2001a) which incorporates ecodesign (European operations) (Phelan, 2002) or Design for Environment (US operations) and is part of an overall Product Stewardship programme (Smith, 1997). Elements incorporated in this approach include:-

- Provision of leased equipment;
- Extended Product Life concept through
  - ⇒ Modular design
  - ⇒ Design for repair
  - ⇒ Design for upgradeability.
- Product design and choice of raw materials to facilitate recovery, disassembly, reuse and recycling;
- Use of reduced raw materials;
- Waste reduction ;
- Energy efficiency e.g. in line with the *Energy Star, Blue Angel* and *Environmental Choice* eco labels and multifunctional products designed to reduce energy use by 20-30%;
- Innovative new products in development e.g. SMART Paper, a reusable electronic paper;
- Operation of a Green World Alliance for consumables;
- Design to facilitate recovery, reuse, recycling largely through remanufacture (Xerox, 2001a and 2002).

Key aspects of this approach are the extended product life, recovery, remanufacture and recycling elements built into the product design. Xerox also refers to this approach as Asset Recycle Management (ARM) illustrating the value placed on end of life equipment/components as an asset.

> *"Asset Recycle Management provides the leadership, strategy, design principles, operational and technical support to maximize global recycling of parts and equipment, resulting in a major competitive, as well as environmental advantage for Xerox"* (Indigo, 2001, p. 1).

This mission has been built into the company's global organization with an ARM Vice President responsible for achieving 100% recyclability of all manufactured parts and assemblies. Remanufacturing to high quality standards and resale to new users is designed to extend the life of equipment several times and reduce demand on virgin resources.

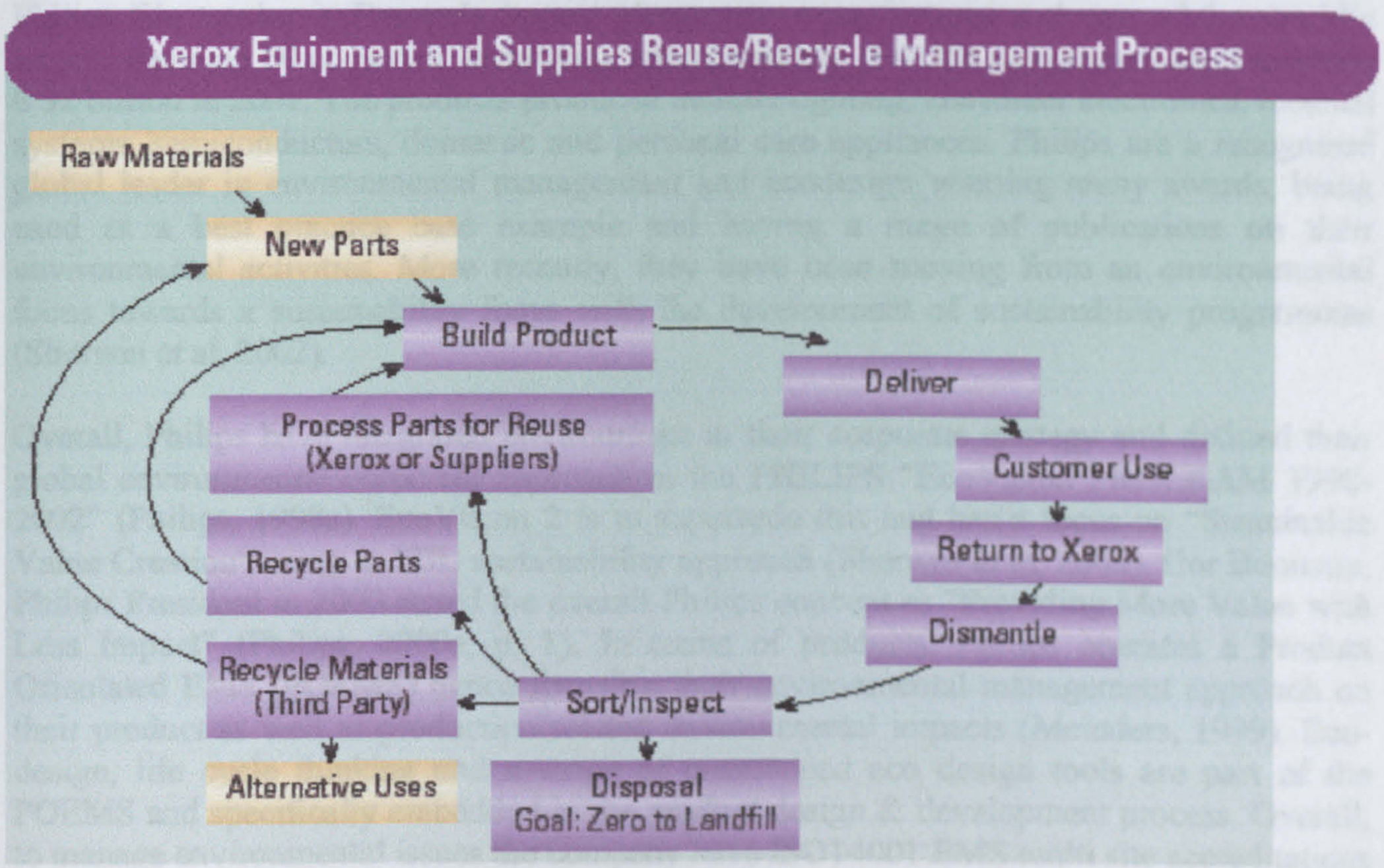
> *"Xerox chooses to evaluate products on the basis of quality and performance, not on the degree of virgin material used . . ."* (Indigo, 2001, p. 1).

The initiative is designed to streamline the process by which returned machines are reconditioned, thus increasing return on investment.

Xerox operates a global remanufacturing process (Smith, 1997). There are currently four Xerox recovery and remanufacture plants worldwide e.g. Xerox in Venray, Holland. **Figure A6.1** illustrates the closed loop recovery, reuse and recycling process involved. Virgin raw materials are used to manufacture product. At the Xerox product end of life, it is

taken back by Xerox. This is especially effective for commercially leased Xerox photocopiers where this is part of the service provided. On take back the product is disassembled and segregated into different streams for reuse, recycling, treatment or disposal as relevant. Xerox highlights their aim as zero disposal to landfill (Xerox, 2001a). The reusable components are introduced into the manufacturing process as raw materials for new or refurbished Xerox product. Overall, the approach yields good results with approximately three quarters of the components reused and for some parts up to 98% recycled (Ecolife, 2002).

Figure A6.1 Xerox Recovery and Remanufacture (Source: Xerox, 2001a)



Through these elements the environmental impacts of Xerox products are reduced. For example in 2000, 160 million pounds of waste were recovered from Xerox products for remanufacture (Xerox, 2001a). On a commercial basis the "Sustainable Product Design" approach has been successful with the company estimating it has added hundreds of millions of dollars to its bottom line since ARM was formally started in 1991 (Indigo, 2001). In 2000, $27 million cost savings was attributed to this approach (Xerox, 2001).

2.0 PHILIPS ELECTRONICS





(Philips,1998a)

Philips Electronics is Europe's largest electronics manufacturer and one of the world's largest spanning 60 countries, employing approximately 184,000 with annual sales totalling € 32 billion in 2001. The products produced include lighting, consumer electronics, medical systems, semiconductors, domestic and personal care appliances. Philips are a recognised global leader in environmental management and ecodesign winning many awards, being used as a best practice case example and having a range of publications on their environmental activities. More recently, they have been moving from an environmental focus towards a sustainability focus with the development of sustainability programmes (Sherwin et al, 2002).

Overall, Philips have integrated environment in their corporate strategy and defined their global environmental corporate approach in the PHILIPS "EcoVision PROGRAM 1998-2002" (Philips, 1998a). EcoVision 2 is to supersede this and has a focus on "Sustainable Value Creation" using a TBL sustainability approach (Sherwin et al, 2002). Cor Boonstra, Philips President in 2000 stated the overall Philips concept as "Providing More Value with Less Impact" (Philips, 2000a, p. 1). In terms of products, Philips operates a Product Orientated EMS (POEMS) hence focusing their environmental management approach on their product as well as production related environmental impacts (Meinders, 1999). Eco-design, life cycle thinking and a range of customised eco design tools are part of the POEMS and specifically embedded in the product design & development process. Overall, to manage environmental issues the company have ISO14001 EMS multi site accreditations (Meinders, 1999). Philips operates a quality programme Philips Business Excellence (PBE) in line with the EFQM model. Environmental management, ecodesign and sustainability programmes integrate with this quality system (Sherwin, 2002).

Characteristics of the Philips ecodesign approach are:-

- Use of corporate environmental strategies and roadmaps;
- Integration of ecodesign in business systems;
- Use of cross functional teams;
- POEMS;
- Development of Green Flagship products;
- Use of customised ecodesign methods and a range of tools;
- Internal and external communication of environmental achievements
- Strong interaction along the supply and value chain;
- Strong marketing of the "environmental" aspects of Green Flagship products;

Philips has produced general environmental and eco-design publications to communicate their approaches as well as providing "how to" guides for industry to include:-

- Eco-vision Manual (Philips, 1998a);
- Point of No return manual & CD (Philips,1998b);
- Greening your Business Philips ((Philips, 2000b).

From a marketing perspective, they are a leader in marketing the environmental benefits of their products (Ottman, 2002) with green being part of the Philips brand positioning (Stevels, 2000a). Examples include the Philips Marathon long life light bulb illustrated in **Figure A6.2**. This product directly markets the environmental benefits and cost benefit to the consumer in terms of energy savings using language such as:-

- Energy Savings - uses 75% less energy
- First Compact Fluorescent Lamp with US EPA Energy Star Logo eco label
- Saves average consumer $26 in energy costs over its lifetime.

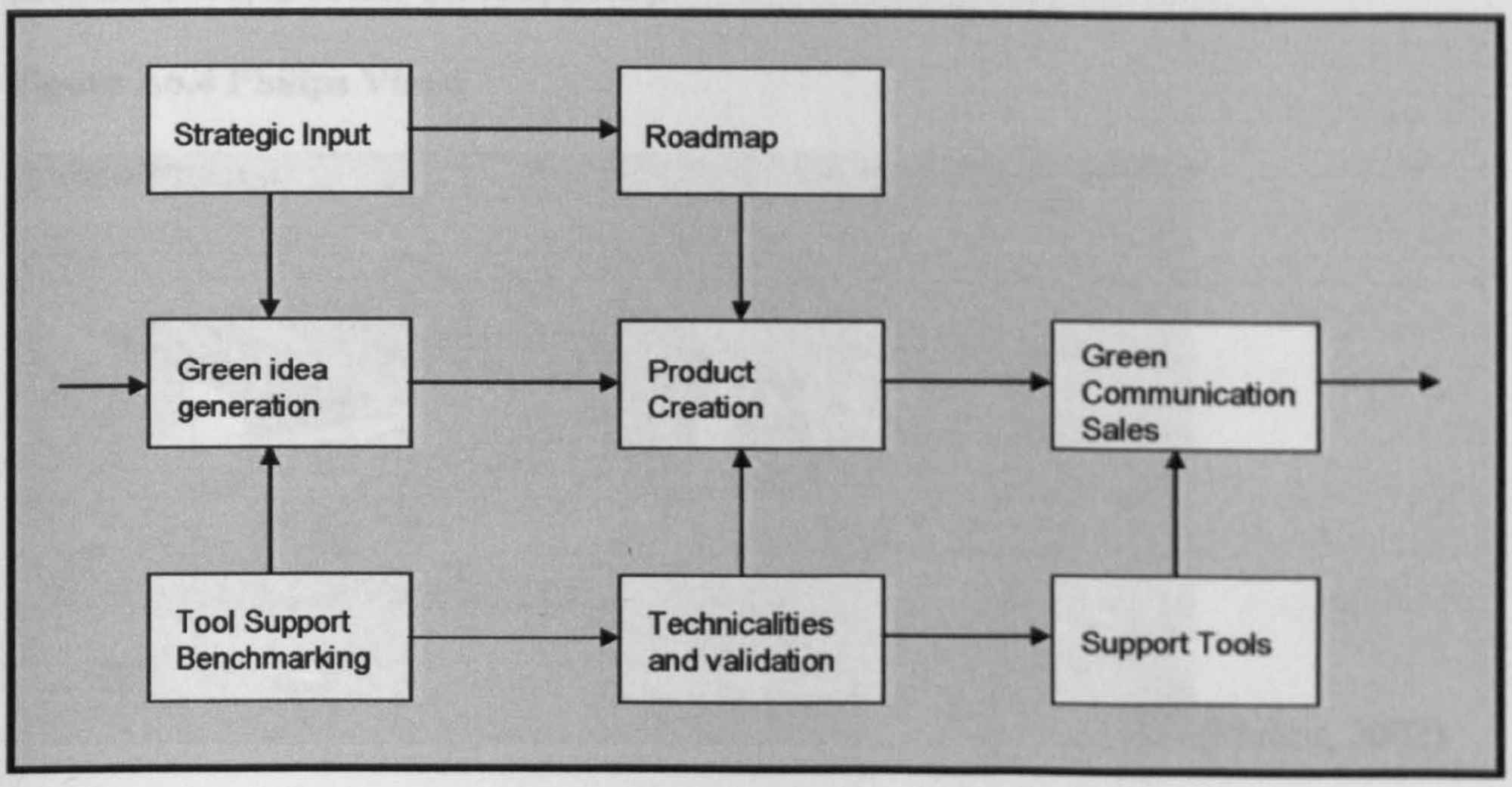
Figure A6.2 Philips marathon Light Bulb



(Philips, 2002)

The implementation of the ecodesign activities at Philips have undergone transitions since their introduction moving from a "design focused activity", to a "product and design management" focussed approach, to a strategic approach embedded in all levels of the business (Sherwin et al, 2002, p. 2). **Figure A6.3** illustrates a Philips model for the overall process of embedding ecodesign into the business processes (Stevels, 2000)

Figure A6.3 Philips illustration for Embedding Ecodesign of products into the business (Source: Reproduced from Stevels, 2000)



The importance of incorporating environment and ecodesign specifically in the corporate strategy and roadmaps, e.g. EcoVision are highlighted as important success factors. Targets for increasingly applying ecodesign to product lines were set and developing increasing numbers of Green Flagship products per business unit. In terms of the ecodesign process, green idea generation focuses on developing environmental product options exclusively. This incorporates environmental benchmarking of selected products against competitors, brainstorming activities to identify the environmental opportunities and options. Once these environmental options are identified they are assessed for feasibility in line with other business criteria (e.g. technical feasibility, cost, customer benefit, environment etc.) and a specification for the product is developed. A communication and green marketing strategy is then developed to ensure effective internal and external communication of the product. A range of customised tools support these activities to include data collection, brainstorming, benchmarking and assessment tools (Stevels, 2000; Stevels, 2000a, Ishii and Stevels, 2000; Ecolife, 2002; Cramer and Stevels, 2000).

Under the Philips Ecovision program, environmental improvements in ecodesigned Green Flagship products and their marketing and sales focus on one or more of the following "Green Focal Areas" (Philips, 2000b):-

- Weight (reducing raw material volumes);
- Hazardous substances ;
- Recycling and disposal;
- Energy consumption;
- Packaging.

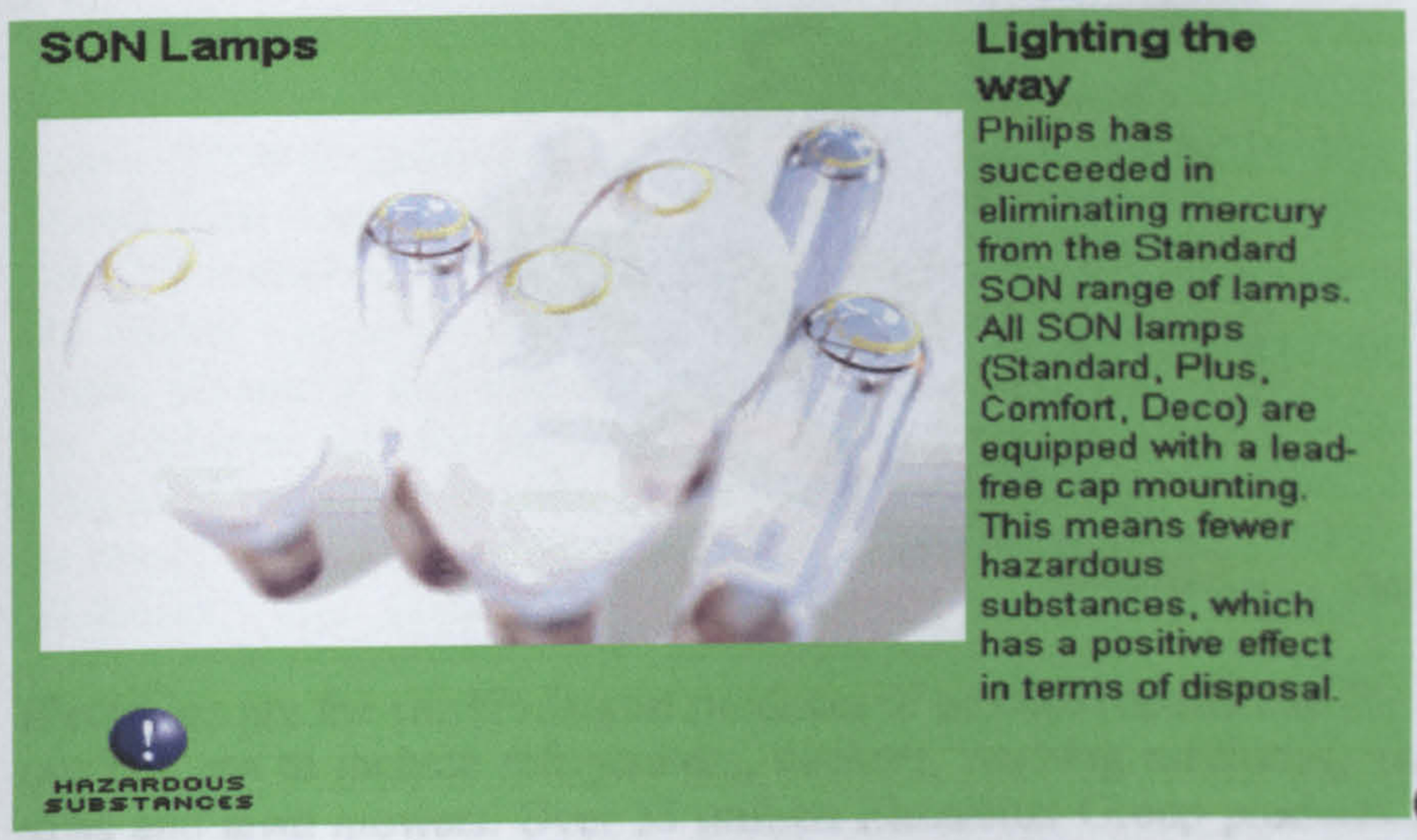
Examples of Philips products illustrating benefits in these Green Focal Areas are illustrated in **Figure A6.4– A6.6** (Philips, 2002). In addition to environmental benefits, the Green Flagship products have led to an increase in market share of 2 % and profit margins of 3% (Ecolife, 2002; Ishii and Stevels, 2000).

Figure A6.4 Philips Video



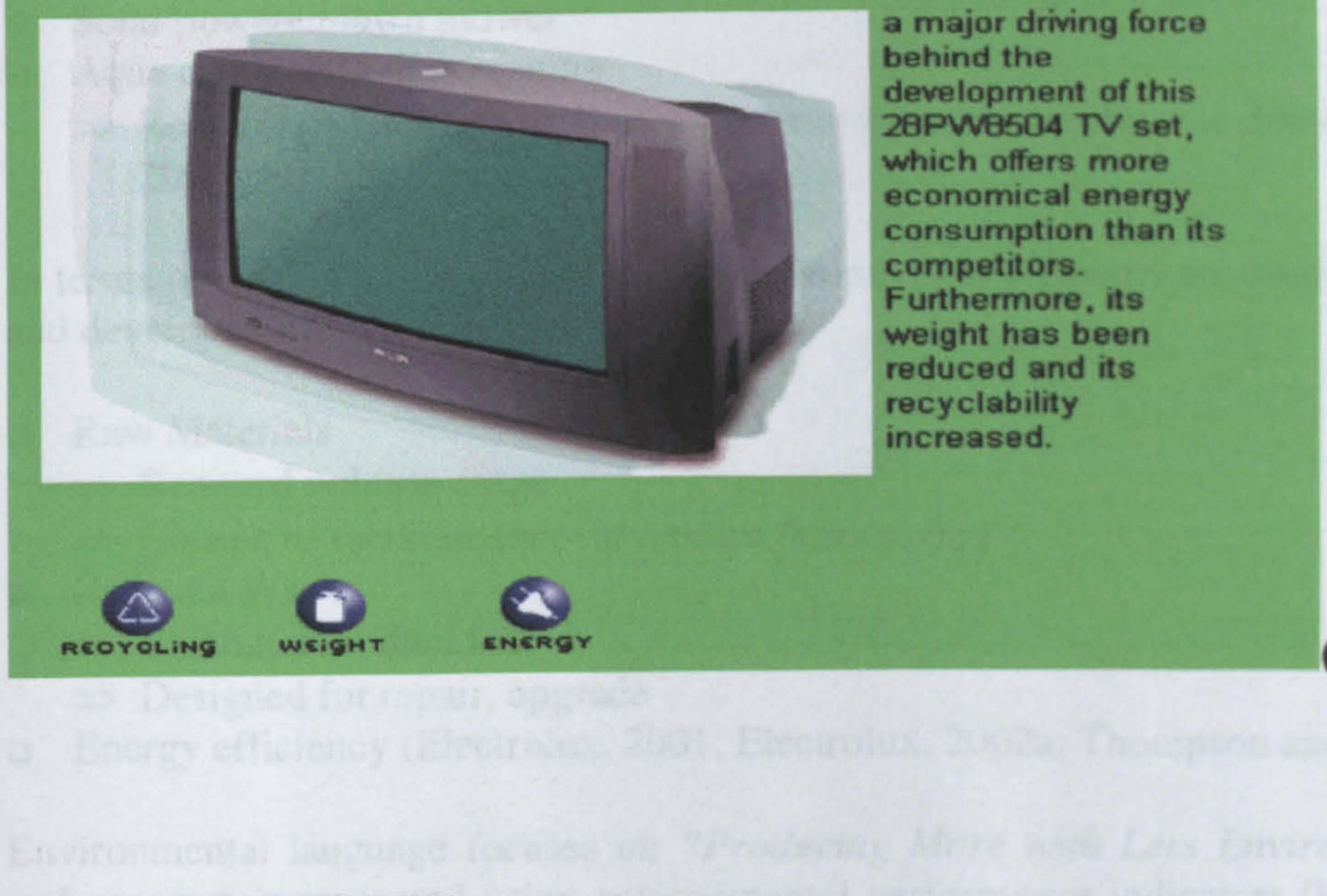
(Philips, 2002)

Figure A6.5 Philips Lighting



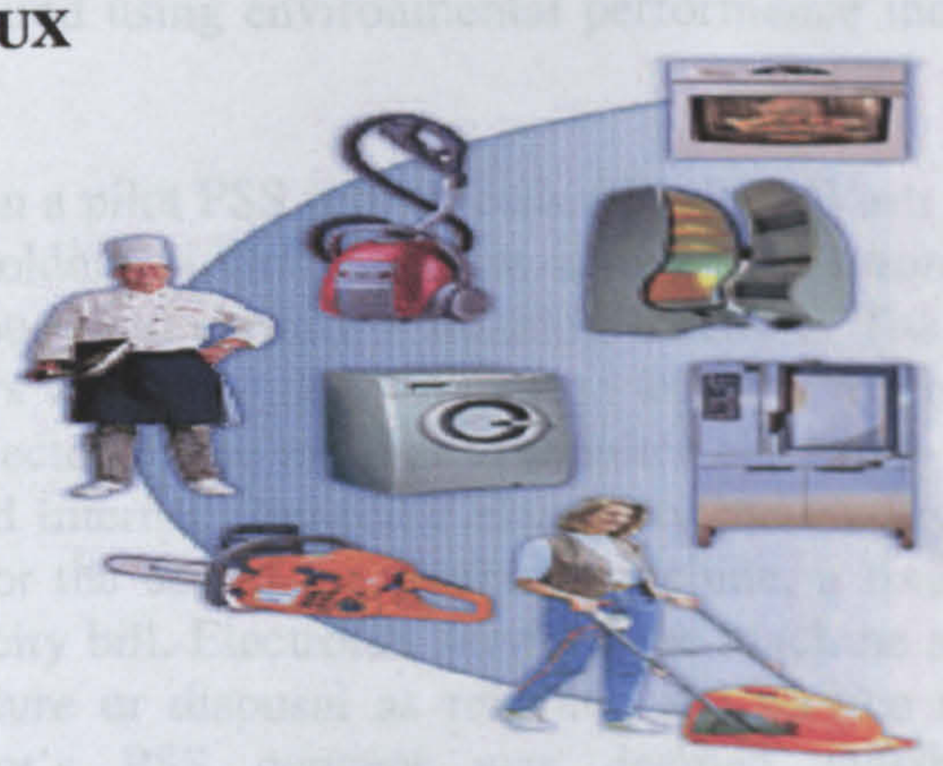
(Philips, 2002)

Figure A6.6 Philips TV



(Philips, 2002)

3.0 ELECTROLUX



(Electrolux, 2002)

Electrolux are the world's largest producer of powered appliances for kitchen, cleaning and outdoor use to include refrigerators, cookers, washing machines, vacuum cleaners, chain saws and lawn mowers. Over 55 million Electrolux Group products are sold per year to a value of approx. $ 14 billion in more than 150 countries around the world (Electrolux (2002). Electrolux operate a Corporate Social Responsibility (CSR) programme incorporating health and safety, sustainable investments and the provision of education and healthcare. Since 2002, an Electrolux Workplace Code of Conduct has operated defining minimum acceptable working standards relating to social and environmental issues for manufacturing and sale of Electrolux products (Electrolux, 2002a). The overall environmental strategy is a POEMS approach incorporating products and processes (Thompson and Sherwin, 2001). Where markets are suitable, Electrolux provide a PSS approach through the lease of white goods (washing machines) and upgrade, repair

services. Some products are produced and marketed on an environmental basis. These include:-

- Solar powered lawn mower
- Aqua cleaning in dry cleaning
  - ⇒ Replacing perchloroethylene with water based biodegradable detergents (Electrolux, 2001).

In terms of their products the following environmental elements are incorporated in design and development:-

- Raw Materials
  - ⇒ Reduced volume usage
  - ⇒ Chosen to facilitate recovery, reuse & recycling
- Reduced Waste
  - ⇒ Extended Product Life
  - ⇒ Designed for repair, upgrade
- Energy efficiency (Electrolux, 2001; Electrolux, 2002a; Thompson and Sherwin, 2001).

Environmental language focuses on *"Producing More with Less Environmental Impact"* and progress is measured using environmental performance indicators (Electrolux, 2002a, p. 1).

In 1999, Electrolux ran a pilot PSS project called Pay per Wash in Gotland, Sweden. In this project, 7000 householders in Gotland were sold the function of a washing machine as distinct from each household owning a washing machine. The arrangements for the pilot were that householders were provided with a free washing machine, paying for installation. The washer was connected to the internet to monitor electricity consumption. Gotland was chosen because it had internet connected electricity meters installed in 7000 households. The consumer paid for the use of the washing machine, a fixed fee per cycle which was charged to the electricity bill. Electrolux serviced the machine and at end of life take back, for reuse, remanufacture or disposal as relevant. All service related costs were paid by Electrolux. The pilot's PSS concept was deemed feasible by the company on environmental, technical and economic levels, however, transfer to other locations requires suitable infrastructure, consumer interest etc. (Mont, 2001)

A Green Range used to measure profitability of environmental products showed products with the best environmental performance accounting for 16% of total units sold in Europe and 22% of gross profit (Electrolux, 2002a)

On the social side, the Electrolux Workplace Code of Conduct incorporates the following social issues and applies to all people involved in manufacturing and sale of Electrolux products (to include all locations, suppliers and sub-contractors):-

- child labour,
- forced labour,
- health and safety,

- non discrimination
- harassment and abuse
- working hours
- compensation
- freedom of association (Electrolux, 2002a).

4.0 ROHNER TEXTIL AG



(Rohner Textil, 1998)

Rohner Textil AG is a Swiss SME upholstery manufacturer. They operate a textile mill & dyeing plants. Among other products, they produce Climatex® Lifecycle, a compostable, environmentally sound upholstery fabric and Climatex® LifeguardFR, a fire resistant biological nutrient upholstery fabric. *Rohner Textil AG* manufacture Climatex® Lifecycle in conjunction with US partners Design Tex Inc. and Carnegie who initiated and licensed the concept respectively (Global Nature Fund, 2000). *Design Tex Inc.* fabric manufacturers have produced the *William McDonough Collection (I, II, III)*, biological nutrient upholstery fabric (Climatex® Lifecycle™).

The company strategy is defined in "Path Towards a Sustainable Company (1998 -2008)" (Rohner Textil, 1998). Sustainability is built into this strategy as a core goal. The main characteristics of the *Rohner Textil AG* approach under this strategy include the following:-

- TBL (environment, social and economic) aspects incorporated in a lifecycle approach focusing on all processes & products;

- A "Virtual System Network" incorporating ISO 9001, ISO14001, EMAS and "Life cycle Development (vs. LCA);

- Application of life cycle thinking up & down the supply chain to include fabric manufacturers Design Tex Inc., resulting in the development of many lucrative partnerships (Rohner Textil, 1998; Kalin, 2002);

- Use of McDonough Braungart Design Chemistry (MBDC) Sustainable Design Protocol & Cradle to Cradle Design™ approach as outlined in **Chapter 4**.

The Climatex® Lifecycle fabric has been developed using this approach. The fabric is used in climate control seating e.g. airplanes, trains, and offices. As such, integrity, durability, diversity in design and colours are key functional criteria. The environmental benefits of the product include the following:-

- Raw Materials & Extraction
  - ⇒ The fabric is generated from the natural fibre Ramie (a plant similar to linen) and wool. Ramie was chosen as a natural alternative to polyester which would be traditionally used for this type of product. Product designed organic agricultural processes for raw materials production are only used. The wool is only sourced from free range sheep. The wool and ramie fibres guarantee a climate control seating which takes up moisture from the user and transports it throughout the fabric.
  - ⇒ The dyes & chemicals used in the production process must meet the following criteria:-
    - o non mutagenic, non carcinogenic, non bio accumulative
    - o no heavy metals or persistent toxins.

- Production Process
  - ⇒ Reduced resource usage through water and energy minimisation measures
  - ⇒ Minimisation of waste water volume generated and treatment to potable water quality standards.
- Waste
  - ⇒ The fabric is compostable & biodegradable which reduces the impacts of end of life disposal (Rohner Textil, 1998; Kalin, 2002).

The product functionality is designed with social benefits in mind in terms of the climate control characteristic which maintains a comfortable temperature and is breathable. In terms of social impacts the main focus is on producing a product with no adverse health implications due to the raw materials used.

As illustrated in **Figure A6.7** below both the Climatex® Lifecycle and Climatex® LifeguardFR rank as "Optimized" on the MBDC Five Dot Optimisation Scale (for more information on the scale see **Appendix 5**).

Figure A6.7 MBDC Optimisation Ranking of Climatex® Lifecycle and Climatex® LifeguardFR (Source: reproduced from MBDC, 2002)

Rohner Textil

● ● ● ● ○	*Climatex® Lifecycle™*, biological nutrient upholstery fabric
● ● ● ● ○	*Climatex® LifeguardFR™*, fire-resistant biological nutrient upholstery fabric
Preferable	● ● ○ ○ ○
Fully Assessed	● ● ● ○ ○
Optimized	● ● ● ● ○
(BEST)Fully Eco-Effective	● ● ● ● ●

On the economic side the product is the same price as other high end similar upholstery products. Overall the company see their sustainability strategy as commercially successful and responsible for changing them from a struggling company to peak, award winning performance (Kalin, 2002).

5.0 WILKHAHN

Figure A6.8 Wilkhahn Picto chair (Source: Wilkhahn, 2003)



Wilkhahn provide a PSS offering, including consultancy, to provide customised customer furniture solutions, office furniture (chairs, seating units, tables) and service elements to include repair, reuse, waste disposal and recycling. Operating in Germany since 1907, it has expanded into an internationally operating company with a sales and distribution network in over 35 countries. Manufacturing takes place in Germany, Spain, Australia, Brazil, Japan, USA and South Africa. Wilkhahn has over 600 employees (Wilkhahn, 2003).

Wilkhahn are recognised for their innovative sustainability practices especially regarding environmental protection (Becker and Charter, 1997). Environmental responsibility extends to all products and services, production sites, corporate areas and activities, to include incorporation of environmental and social criteria in site architecture and construction.

Their sustainability policy is seen as key to their internal brand image and green communication activities internally and externally are significant. However, their sustainability practices are seen as inherent to the company philosophy and are communicated as such as distinct from an add on (Becker and Charter, 1997). They are the winner of numerous awards e.g. for the Picto office chair (as illustrated in **Figure A6.8**) for ecologically orientated product design due to its 95% recyclability (Wilkhahn, 2000; Skoecz, 1999; Wilkhahn, 2001; Becker and Charter, 1997).

In terms of company strategy Wilkhahn has three key philosophies – design, social responsibility and ecology (Skoecz, 1999). *"For Wilkhahn the basis of all entrepreneurial activity is the preservation of the ecological fundamentals of life, securing entrepreneurial independence and consequently securing jobs, respecting human dignity and due observation of social and ethical rules". "The balance between economic, ecological, social and cultural goals to secure desired independence, shapes corporate culture and the way in which Wilkhahn rates success"* (Wilkhahn, 2000, p.2).

In terms of product and service development, the focus is innovation. Ecologically orientated design and development aimed at *"developing sustainable products, to increase their utility value and to reduce waste"* is their guiding principle of innovation (Wilkhahn, 2000 p. 8). The development of products and services largely incorporates an EPD approach. Key areas focused on are extending product life through longevity focused design, construction and engineering techniques, design for repair and upgrade, dematerialisation, detoxification, take back, reuse, recycling and disposal. The FS-Line chair illustrated in **Figure A6.9** is an example of a result of the ecologically orientated design and development process. It is designed for repair, upgrade and recycling, has a 21% reduction in solvent based glue due to alternative gluing and joining techniques and is cost effective for the customer.

Figure A6.9 Wilkhahn FS-Line chair (Source: Wilkhahn, 2003)



Overall environmental performance is managed using an EMS accredited to ISO14001 and EMAS. This approach integrates with the company ISO9001 quality management system. Supply chain interaction is a key element of the product and service design and development processes incorporating suppliers of raw materials, components and sub assemblies produced to a predefined Wilkhahn specification. These specifications include meeting environmental questionnaires for suppliers. Close relationships with specialised

suppliers and the use of cross functional teams internally and across the supply chain are characteristics of the supply chain aspects in product and service development (Wilkhahn, 2001).

Social responsibility is part of the corporate mission. The company defines its social responsibility activities as incorporating the plant site architecture, employee policies, support and involvement in community projects as well as extensive information dissemination activities to include guided tours, lectures and publications. Stakeholder interaction incorporating customers, employees, distributors, suppliers and the public is central to the Wilkhahn approach. It was one of the earliest companies to produce a sustainability report "Wilkhahn Added Values" in 2000. Other sustainability related publications include:-

- Wilkhahn Green - A company in the process of change; ecological product profiles ecobalance
- Ecological Product Profiles (for all Wilkhahn ranges)
- Environmental Statement 2001 (Wilkhahn, 2001).

APPENDIX 7: Draft SPSD Sustainability Assessment Checklist

SPSD Criteria	Life Cycle	Issues to Consider (as relevant)
Functionality	Function	What is the human need/functionality required?
		How can this be achieved?
		Do you need a product?
		Could this be achieved by a service?
		Options for PSS?
		What are the wider systems in which the options for product, service or PSS will operate?
		Is packaging required?
		Design for durability
		Design for repair and maintenance
		Modular design for maximising upgradeability
		Timeless design compared to short term trends
		Possibilities for recovery for reuse, energy recovery, recycling, treatment and/or disposal
		Possibilities for leasing products on a continuous service contract rather than once off sales
Environmental Impact	Raw Materials	Type of raw materials
		Eliminate or reduce non-renewables usage (Fossil fuels, metals, timber, plastics, paper)
		Substitute scarce minerals for those that are abundant
		Consider long term resource availability
		Substitution of hazardous raw materials for non/less hazardous ones that can be assimilated by natural systems
		Avoid ozone depleting substances and high greenhouse gas emitting substances
		Source renewable resources from sustainably managed restorative ecosystems
		Choose recycled raw materials over virgin materials
		Choose raw materials to facilitate extending product life
		Reduce the volume of materials used Dematerialisation
		Reduce energy usage
		Limit and reduce use of natural resources

		Reduce impacts from extraction, process & transport of raw materials
		Preference for local raw materials
		Design offering to have an extended operating life
		Choose raw materials to facilitate end of life recovery for (in order of priority) reuse, recovery for energy recovery, recycling, treatment and/or disposal
		Minimise the diversity of materials used to facilitate reuse, recycling, energy recovery of final disposal
		Avoid the use of composites
		Reduce the number of components and assemblies
		Reduce land use particularly regarding land consuming materials and infrastructure associated with the offering
		Use in mould material identification labelling
	Production	Use a Cleaner Production approach/technologies
		Eliminate/reduce emissions to air
		Eliminate/reduce effluents
		Eliminate/reduce waste
		Eliminate/reduce packaging
		Opportunities for reuse of production waste as raw material on site
		Opportunities for reuse, energy recovery or recycling of production waste off site
		Eliminate/reduce energy usage
		Use resource as efficiency as possible e.g. energy and water usage, to include recovery and reuse opportunities
	Distribution	Is storage necessary?
		Eliminate/reduce materials and energy use in storage.
		Is transport necessary?
		Volume & nature of transport
		Eliminate/reduce transport distances
		Minimise weight of product and packaging to save space and energy in transport
		Type of fuel usage
		Eliminate/reduce emissions to air
		Eliminate/reduce waste
	Consumption	Eliminate/reduce waste from product
		Eliminate/reduce waste from packaging
		Eliminate/reduce energy consumption in standby and operational modes

		Use customer communication mechanisms to maximise environmental performance during use e.g. energy use, take back arrangements for consumables, packaging and product
		Eliminate/reduce material consumption e.g. consumables required during operation
	End of Life	Extend offering life through repair, upgrade and maintenance
		Recovery for reuse of complete product (e.g. secondary market)
		Recovery for disassembly & recovery of components for reuse and remanufacturing
		Recovery for disassembly & recovery of components for recycling, energy recovery or treatment/disposal
		Guarantee and convenience of take back for recovery for the end user?
		Reduce material and energy use in reuse, recycling, treatment/disposal options
		Eliminate/reduce material, energy use, waste & emissions from recovery, disassembly, reuse, recycling, treatment/disposal options
		Take back of packaging for reuse or recycling?
		In final disposal closing biological cycles e.g. biodegradable
Social Impacts	Raw Materials	Are the raw materials extracted/processed in the developing world?
		Ownerships rights
		Are the trading arrangements fair and equitable?
		Are their political and social implications from raw material extraction and processing?
	Production & Distribution	Employee conditions of work at company and work in sub contract companies
		Respect human rights , values and their different cultural contexts throughout all operations and global locations
		Implement diversity policies to eliminate discrimination
		Provision of safe, secure working conditions
		Adopt fair labour practices to include equality and exclude child labour or forced labour
		Provide fair, reasonable remuneration for employees
		Ensure health and safety to include physical and mental well being

		Provide access to training, and create an enabling environment for learning and development
		Support health promotion and education
		Impact on local community e.g. local residents, political or social implications
		Investment in development of local community e.g. use of local service providers and supplies
		Investment in local community e.g. financial supports (charities, schools) and sharing expertise
	Consumption	Adverse health/safety impacts for the local community
		Adverse health/safety impacts for the global community
	End of Life	Adverse health/safety impacts for the local community
		Adverse health/safety impacts for the global community
	All phases	Compliance with the company's ethical code of conduct
		Consistency between company policies, communications, marketing and actual activities and offerings
		Communication with local and global community in terms of transparency and accountability e.g. reporting mechanisms
Economic Aspects	All phases	Internalise environmental and social externality costs (e.g. end of Life recovery, reuse/treatment/disposal) by assigning an economic value to them. Incorporate these costs or benefits in the overall economic assessment of the offering
		Incorporate the economic impacts on risk and corporate governance of adverse environmental and social performance
		Incorporate the wider economic impacts of the companies activities and offering on society e.g. investment in local community
		Incorporate intangible assets e.g. reputation and brand
		Is the offering cost effective?
		Does the offering cost the same/less than competing versions?
		Is their potential for a new source of profit from service or product service combinations?

Technical specification	All phases	Does the product &/or service provide the required functionality?
		Is it technically feasible to manufacture/provide?
Quality	All phases	Does product &/or service meet defined quality specifications?
		Is it of suitable integrity, durability?
Legal/industry requirements	All phases	Does product &/or service meet required legal/industry standards? e.g. • Environmental • Health & Safety • Product/Service standards • CE Marking • Standards/legislation in export markets
		Consider whether existing environmental labelling schemes are applicable for the product &/or service
Market requirements	All phases	Does it meet customer requirements?
		Are there competing offerings?
		Is it a domestic/export market?
		Does sustainability contribute to the marketing/brand? How?
		Information/Communication for marketing campaign

APPENDIX 8 SPSD EVALUATION CASE STUDY INFORMATION COLLECTION TEMPLATE

1.0 SPSD EVALUATION CASE PROFILE

- Sector
- Companies Involved
    - Initiating Company
    - Company taking responsibility for SPSD implementation
        - ⇒ Size, Supply Chain Role & customer
    - Other involved companies
        - ⇒ Size and Supply Chain Roles
- Existing sustainability related culture in involved companies strategy and activities
    - EMS
        - ⇒ EMS Type (ISO14001, EMAS, non accredited)
        - ⇒ Does EMS incorporate improving the environmental performance of the products/services provided?
        - ⇒ If so, how? e.g. ecodesign etc…
- Other management systems?
- Product (s) manufactured
- Services provided
- Customers
- Role in supply chain
- Previous experience incorporating sustainability into the development of products and/or services

2.0 DESCRIBE SPSD EVALUATION CASE

- Aims & Objectives
- SPSD stages implemented
- As per SPSD approach or any differences

- Overall usefulness of SPSD based on qualitative, customised approach
    - Simple, flexible
    - Customisation
    - Qualified vs. quantified
    - Practical
    - Ease of use for participants

3.0 DESCRIBE THE OUTCOME

- Offering developed
  - Product, Service, PSS, other?

- Sustainability Impact
  - Environmental Impact e.g.
    - ⇒ Increase/Reduction of material intensity
    - ⇒ Increase/Reduction of energy intensity
    - ⇒ Increase/Reduction of toxic/harmful material or materials of concern
    - ⇒ Others
  - Social Impact e.g.
    - ⇒ Improvement/not of health and safety for employees and consumer/society
    - ⇒ Improvement/not of workplace quality
    - ⇒ Others
  - Economic Impact e.g.
    - ⇒ Improvement / not of efficiency (i.e. a certain positive relation of costs and benefits in monetary terms)
    - ⇒ Improvement /not of productivity (i.e. a certain positive relation of output and input in quantitative terms)
    - ⇒ Others
    - ⇒ Commercial viability of the offering

- Other Business Impacts
  - Supplier/customer relationship
  - Intellectual property
  - Capability building
  - Marketing potential of sustainability aspects
  - Environmental Product Declarations or other third part validations obtained/viewed as useful for marketing e.g. eco labels...
  - Relevance to corporate reputation

4.0 DRIVERS FOR THE CASE

- Legal/Compliance
- Market
- Financial
- Other

5.0 SPSD IMPLEMENTATION PROCESS

Researcher to list the experiences and views of the company(ies) for each SPSD implementation stage regarding effectiveness and usefulness. Guides for issues to be included are bulleted per section.

A. PLANNING

INTRODUCTORY INFORMATION PROVISION

- Participants
- Meeting(s) held
- Content
- Understanding of participants, difficulties experienced etc..
- Contribution to commitment, training etc....

STRATEGY & INTEGRATION

- Integrated into corporate strategy
  - How
  - Participants
  - Meeting(s) held
  - Strategy policy resulting
  - Language used
- Integrated into Sustainability Management System/EMS
  - New or changes to Environmental Policy Statement
- Integrated into Quality Management System
  - New or changes to Quality Policy Statement
- Integrated into Health and Safety Management System
  - New or changes to H&S Policy Statement
- Integrated into Product conception, design and development processes
- What were the pros and cons of the strategic level commitment and integration
  - Internally
  - Cross supply/value chain

MANAGEMENT, ORGANISATION & COMMUNICATION

- Project team & roles
  - Company taking overall responsibility for SPSD implementation
  - Project Manager: role, responsibility, accountability
  - Representatives from which business functions (product design/development, quality, operations, environment, finance, purchasing etc...)
  - External to Company taking overall responsibility for SPSD implementation
  - Supply/value chain representatives and role in chain
  - Consultants: role and expertise

- Timing of project team identification and completion
  - at which SPSD stages
  - how did this vary for existing offering vs. new offering
- Multidisciplinary aspects
- Understanding of non environmental team members
  - Financial, designers, operations, marketing etc…

- Time and cost allocation for personnel
  - Allocation per SPSD stage
  - Time from product conception to market
  - Differences from previous product &/service development implementations
  - Impact of subsidy on cost allocation
  - If increased/decreased cost what was the overall economic impact for the offering development

- Effectiveness of Communication
  - Within company taking overall responsibility
  - Cross supply chain

- Language/terminology used for approach (SPSD , ecodesign , DfE other etc..?)
- Language used per case for SPSD concepts if different
- Is use of certain SPSD related terminology confusing to personnel? How does this vary for sustainability related vs. sustainability related personnel?
- Listing of meetings per case, which SPSD stages, activities conducted, participants

B. OFFERING (PRODUCT, SERVICE OR PSS) DEVELOPMENT

CONCEPT DEVELOPMENT

- Starting with the function to be provided
- Consideration of functionality & options for PSS

- Considering the wider systems infrastructure

- Initial Sustainability Assessment
  - Determine Life Cycle Stages
  - Assessing the initial TBL sustainability impacts

- Full Sustainability Assessment

- Optimisation of TBL with traditional product criteria?
  - Economic
  - Environmental
  - Social

- Which was the priority weighting?
  - Economic
  - Environment
    - Compliance issues (e.g. WEEE/ROSH/ELV/Packaging etc.)
  - Social
  - Customer requirements
  - Market demand
  - Technical feasibility

- Assessing environmental impacts – what is considered?
  - Raw materials
  - Production
  - Distribution
  - Consumption
  - End of Life

- Assessing social impacts – what is considered?

- Other product criteria considered?
  - Quality
  - Technical feasibility
  - Cost
  - Customer requirements
  - Legal/standards requirements

- Use of SPSD Sustainability Assessment Checklist
- Use of other tools, methods, specifications etc.. List these below.

_____
_____
_____
_____

- Life cycle thinking

  - Life cycle stages per case
  - Role & location of each supply/value chain organisation

- Life Cycle Assessment (LCA)?
  - Time factor
  - Availability of data to do effective LCA
  - Value of end result

  - Do requirements of customer for product information force requirement for LCA?

- Preference for qualitative/quantitative approach and usefulness of results

- Requirement for customised assessment approach/tools etc...
- Difficulty in accessing required information
- Understanding of participants, difficulties experienced etc..

Assessing Supply Chain Dynamics, Supply Chain Interaction And Co-Ordination

- Control over which product lifecycle phases
- Ability to change product specification & process for same
- Is it more effective working with supply chain players as team?
  - Customers
  - Suppliers
- What was the view of customer re your SPSD improvements?
- Was sustainability improvement seen as supplier requirement by customer?

DETAILED DESIGN

- Project team members involved
- Meetings held
- Detail experiences
- Changes from previous experiences at this stage

TESTING/PROTOTYPE

- Project team members involved
- Meetings held
- Detail experiences
- Changes from previous experiences at this stage

PRODUCTION

- Project team members involved
- Meetings held
- Detail experiences
- Changes from previous experiences at this stage

OFFERING LAUNCH

- Project team members involved
- Meetings held
- Detail experiences

- Changes from previous experiences at this stage

OFFERING REVIEW

- Project team members involved
- Meetings held
- Detail experiences
- Changes from previous experiences at this stage
- Feedback on the sustainability and other criteria of the final offering
- Experiences learnt which can be used to improve future offerings and/or the development process.

C. ONGOING SUPPORTS (Information, Tools etc...)

List ongoing supports provided and used and the role they played

_____
_____
_____

- Usefulness of supports to the implementation process

- Ease of access to supports

- Benefits or difficulties associated with ongoing supports

6.0 OTHER INFLUENCES

- What other aspects influenced the SPSD evaluation cases that have not been considered above?

- Rival/Alternative Explanations

****

Data Sources Used to Complete Template:-

_____
_____
_____

APPENDIX 9: SPSD EVALUATION CASE STUDY SUMMARIES

1.0 CASE 1: ELECTRONIC AUTOMOTIVE COMPONENTS

Sector	Electronics
Case Description	SPSD application to existing electronic automotive component
Offering Developed	Electronic automotive component
Initiating Company (Size, Supply Chain Role & customer)	SME, Tier 2 supplier Tier 1 automotive component manufacturer selling to bluechip OEM automotive manufacturers
Involved companies (Size and Supply Chain Roles)	4 x raw material suppliers (SME & large) 1 x SME component assembler Tier 1 SME customer end OEM customer
Team	
Initiating Company	CEO, Project Manager, R&D Manager, Product design team, Environment Manager, Purchasing Manager, Financial Controller
External to Initiating Company	Raw material suppliers, Tier 1 customer, OEM customer, SPSD Mentor, Environmental Consultant
Existing sustainability related culture in initiating company	ISO14001 EMS
Management Systems e.g. Quality, Environment etc..	ISO14001 ISO9001, QS 9000 Health & Safety
Existing Product Development systems	Yes
Drivers	ELV, WEEE and RoHS[3] directives
Sustainability Impacts	
Environmental Impact	Reduced hazardous substances and improved energy efficiency
Social Impact	Improved health and safety in production and for end of life
Economic Impact	Some cost savings due to eco efficiencies and some cost increases identified. Overall, significant cost savings identified
Commercially viable	Yes, in operation

[3] End of Life Vehicles (ELV)(EC, 2000a), Waste from Electrical and Electronic Equipment (WEEE) (EC,2003a), restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) (EC, 2003b) Directives

Other impacts	Significant competitive advantage Improved supplier and customer relationships Ecodesign award winner Capability building via increased knowledge and skills
SPSD Implementation Stages	As per draft SPSD guide
Supporting tools used	Abridged LCA using LCA Workbench Irish software tool
Supply chain organisation locations	UK, Taiwan, Ireland
Importance of sustainability benefits to marketing/brand	Not important for marketing Important to end OEM customer
Third party validations achieved (e.g. ecolabels)	None
Follow up application to other products and/or services	Incorporation into product and/or service development process on an ongoing basis
Interviewee	Initiating Company , Project Manager (Environment)

Case Summary

In this case an electronic component for cars with sustainability benefits was developed. The case involved the tier 2 SME manufacturer of the component working in conjunction with supply chain companies from raw material suppliers up to the tier 1 customer and end OEM customer. The environmental improvements achieved included:-

- **Dematerialisation of the unit's circuit board components by 40% to include the reduction of hazardous substances in compliance with the RoHS directive;**
- **Assembly and labeling of component to facilitate end of life disassembly in compliance with the ELV and WEEE directives'**
- **Three fold reduction in energy usage.**

The social improvements achieved included improved health and safety relating in particular to materials handling and air quality due to the reduction of hazardous substances used in the product at the supplier as well as the component assembly facility. Health and safety benefits for the end user and end of life recovery operators were also identified.

As a result of these environmental improvements, the product was quicker and more cost effective to manufacture resulting in substantial cost savings and competitive advantage for the company and their customers.

2.0 CASE 2: ELECTRONIC ANALYTIC EQUIPMENT

Sector	Electronics
Case Description	SPSD application to new concept
Offering Developed	None Electronic analytic equipment using a new energy efficient technology commenced but was not completed due to unresolvable technical feasibility problems with the energy technology
Initiating Company (Size, Supply Chain Role & customer)	SME, OEM
Involved companies (Size and Supply Chain Roles)	3 x SME raw material suppliers
Team	
Initiating Company	MD, Project Manager, Product designer, Purchasing Manager and Financial Controller (same person)
External to Initiating Company	Raw material suppliers, SPSD Mentor, Environmental Consultant
Existing sustainability related culture in initiating company	None
Management Systems e.g. Quality, Environment etc..	ISO9001, Health & Safety
Existing Product Development systems	Yes
Drivers	WEEE and RoHS directives
Sustainability Impacts	
Environmental Impact	N/A
Social Impact	N/A
Economic Impact	N/A
Commercially viable	No
Other impacts	Capability building via increased knowledge and skills
SPSD Implementation Stages	As per draft SPSD guide up to detailed design only. At this stage it was clear the technical feasibility problems could not be resolved and the implementation was stopped.
Supporting tools used	None
Supply chain organisation locations	UK, Germany, China, Ireland
Importance of sustainability benefits to marketing/brand	Not important for marketing Important to company reputation

Third party validations achieved (e.g. ecolabels)	None
Follow up application to other products and/or services	No
Interviewee	Initiating Company , Project Manager (General Manager)

Case Summary

The initiating company, a manufacturer of analytic equipment aimed to develop an offering to meet an analytical requirement based on a new energy efficient technology. The SPSD implementation went as far as detailed design where it was stopped at the request of the company. The reason for stopping the implementation was because of unresolvable technical feasibility problems with the energy technology. The company decided that without this technology, coupled with a shift in business priorities, they did not wish to develop an offering and put the implementation of the new offering on hold until a later date.

3.0 CASE 3: PERSONAL COMPUTER (PC) PSS

Sector	ICT
Case Description	SPSD application to existing PCs
Offering developed	PSS to include upgradeable PC & maintenance, repair, upgrade and end of life services
Initiating Company (Size, Supply Chain Role & Customer)	SME, OEM Domestic and commercial consumers
Involved companies (Size and Supply Chain Roles)	7 x raw material suppliers (SME & large) 3 x sub contract assemblers 2 x end of life recycling and treatment operators (SME)
Team	
Initiating Company	MD, Project Manager, Product designer & engineer, Environment Manager, Sales and Purchasing Manager (same person), Financial Controller
External to Initiating Company	Raw material suppliers, assemblers, SPSD Mentor, Environmental Consultant
Existing sustainability related culture in initiating company	Strategy commitment to managing environmental performance
Management Systems e.g. Quality, Environment etc..	ISO14001 EMS development underway Health & Safety
Existing Product Development systems	Yes

Drivers	Company commitment to improving environmental performance of PCs WEEE and RoHS directives
Sustainability Impacts	
Environmental Impact	Dematerialization Reduced hazardous substances in compliance with RoHS directive Improved energy efficiency Reduced waste generation
Social Impact	Improved health and safety aspects in production, for users and end of life recovery due to hazardous substance reduction Improved ergonomics for users
Economic Impact	Some cost savings due to eco efficiencies and some cost increases identified. Overall cost benefit
Commercially viable	Yes, in operation
Other impacts	Improved functionality Improved supplier and customer relationships Capability building via increased knowledge and skills
SPSD Implementation Stages	As per draft SPSD guide
Supporting tools used	Abridged LCA in line with ISO14040-43 Specification for EU Eco label for PCs used as a benchmark
Supply chain organisation locations	Taiwan, China, Poland, USA, Ireland, UK
Importance of sustainability benefits to marketing/brand	Energy Star ecolabel Consideration of EU Ecolabel for PCs
Follow up application to other products and/or services	Incorporation into product and/or service design process for all ranges
Interviewee	Initiating Company , Project Manager (General Manager)

Case Summary

In this case an OEM computer manufacturer worked with supply and value chain companies to develop a PSS for computers. The PSS involved the provision of a modular, upgradeable computer with associated upgrade, maintenance and repair services. Further end of life services to incorporate take back, reuse, remanufacture, recycling and treatment were developed. Environmentally the main benefits included:-

- **Use of raw materials and assembly techniques to increase the reuse and recycling options at end of life;**

- ❑ Extending the operational life of the hardware (up to a potential five years longer than standard computers) via an upgradeable chassis with interface modular port design and upgrade and maintenance service elements;
- ❑ Increased energy efficiency;
- ❑ Elimination and reduction of hazardous substances as feasible in line with RoHS directive;
- ❑ Dematerialisation through reduced raw material usage and extended product life;
- ❑ Reduced waste generation (especially hazardous) through reduced raw material usage, extended product life and increased end of life reuse and recycling.

Social improvements for the end user in terms of improved functionality and ergonomics were identified. Further improved health and safety relating in particular to materials handling and air quality due to the reduction of hazardous substances used in the product. These improvements occurred at the supply chain companies manufacturing components for the product in Taiwan and China as well as the component assembly at the Irish production facility. Health and safety benefits for the end user and end of life recovery operators were also identified.

An overall cost benefit was identified for the customer from the PSS in particular in terms of the repair, upgrade and end of life services. The cost of certain components was higher than the previous versions, but this increased cost was balanced by the reduced materials costs due to the dematerialized design of the PC. Overall, to date the OEM have identified a profit based on sales of the PC and the associated service provision.

4.0 CASE 4: OFFICE SEATING PSS

Sector	Furniture
Case Description	SPSD application to existing office chairs
Offering developed	PSS to include upgradeable office chairs & maintenance, repair & upgrade services
Initiating Company (Size, Supply Chain Role & Customer)	SME, OEM Domestic and commercial consumers
Involved companies (Size and Supply Chain Roles)	4 x Raw material suppliers (SME & large)
Team	
Initiating Company	MD & Project Manager, Product designer, Financial Controller
External to Initiating Company	Raw material suppliers, SPSD Mentor, Environmental Consultant
Existing sustainability related culture in initiating company	No
Management Systems e.g. Quality, Environment etc..	Health & Safety

Existing Product Development systems	No
Drivers	Potential market opportunities
Sustainability Impacts	
Environmental Impact	Dematerialisation Reduction in hazardous substances (solvent based varnishes and paints) Waste reduction
Social Impact	Improved ergonomics for users Less hazardous materials hence improved health and safety in production and for users
Economic Impact	Same operating costs as original office chairs alone
Commercially viable	Yes, in operation
Other impacts	Improved supplier and customer relationships Capability building via increased knowledge and skills
SPSD Implementation Stages	As per draft SPSD guide
Supporting tools used	Abridged LCA using the LCA Workbench Irish software tool
Supply chain organisation locations	UK and Ireland
Importance of sustainability benefits to marketing/brand	Important to Northern European markets
Follow up application to other products and/or services	Incorporation into product and/or service design process for all ranges
Interviewee	Initiating Company , Project Manager (General Manager)

Case Summary

An OEM office furniture manufacturer worked with supply and value chain companies to develop a PSS for office chairs. The PSS involved the provision of a modular, upgradeable chair with associated upgrade, maintenance and repair services. The chair arms, legs and seat were modular to enable repair and upgrade to a different design. The upholstery was designed to be removable to enable upgrades in terms of colour and fabric types as required. The aim was to enable upgrade of the chair to new designs while minimizing the waste generating and extending the lifetime of the main chair structure. Environmentally the main benefits included:-

- **Use of raw materials and assembly techniques to increase the reuse and recycling options at end of life;**
- **Extending the operational life of the chair via an upgradeable modular design and upgrade and repair service elements;**

- Elimination of solvent based adhesives for attaching components through redesign of the components and joining mechanism to eliminate the requirement for adhesives;
- Improvement in safety of materials handling in particular air quality for the employees involved in chair assembly;
- Dematerialisation through reduced raw material usage and extended product life;
- Reduced waste generation through reduced raw material usage, removal of hazardous substances, extended product life and increased end of life reuse and recycling.

The social improvements achieved include improved ergonomics for the user, improved health and safety in production relating in particular to materials handling and air quality due to the reduction of hazardous substances used in the product.

The overall cost of the more sustainable office chair compared to original design was unchanged. The sustainability benefits of the PSS were seen as an important marketing feature for increasing market share for this company in Northern European markets e.g. Scandinavia where environmental benefits of competitor offerings had meant this OEM could previously not compete.

5.0 CASE 5: TONER CARTRIDGES

Sector	Consumer Products
Case Description	SPSD application to existing product
Offering Developed	Reusable toner cartridges
Initiating Company (Size, Supply Chain Role & customer)	SME, Tier 1 supplier OEM office equipment manufacturer
Involved companies (Size and Supply Chain Roles)	2 x raw material suppliers (SME & large) end OEM customer
Team	
Initiating Company	CEO, Project Manager, R&D Manager, Product design team, Operations engineer, Environment Manager, Purchasing Manager, Financial Controller
External to Initiating Company	Raw material suppliers, OEM customer, SPSD Mentor, Environmental Consultant
Existing sustainability related culture in initiating company	ISO14001 EMS
Management Systems e.g. Quality, Environment etc..	ISO14001 ISO EN 9002 Health & Safety
Existing Product Development systems	Yes

Drivers	Pressure for improved environmental performance from customer subject to WEEE/RoHS compliance
Sustainability Impacts	
Environmental Impact	Reduced hazardous substances Reduced material usage and waste generation due to extended life of product (reusable 6 times and then suitable for reuse as raw material) vs. previous non reusable product Reduced material usage due to reduction of raw materials to 1 reusable plastic vs. a mixture of raw materials
Social Impact	Improved health and safety in production and for end of life
Economic Impact	Significant cost savings identified
Commercially viable	Yes, in operation
Other impacts	Significant competitive advantage Improved supplier and customer relationships Capability building via increased knowledge and skills
SPSD Implementation Stages	As per draft SPSD guide
Supporting tools used	Abridged LCA based on ISO14040 -43
Supply chain organisation locations	China, UK, Ireland, USA
Importance of sustainability benefits to marketing/brand	Important in terms of good environmental performance to end OEM customer
Third party validations achieved (e.g. ecolabels)	None
Follow up application to other products and/or services	Incorporation into product and/or service development process on an ongoing basis
Interviewee	Initiating Company , Project Manager (Product Development Technical Director)

Case Summary

This case applied SPSD to an existing toner cartridge for multifunctional office equipment to develop a more sustainable option. The existing non reusable product was replaced by a returnable, reusable cartridge which could be reused at eventual end of life as raw material for further cartridges. The environmental benefits resulting included:-

- **Reduced material usage and waste generation due to extended life of reusable product vs. previous non reusable design;**

- Reduced material usage due to reduction of raw materials in the product to one reusable plastic type vs. a mixture of raw materials as well as enabling reuse of product at end of life as raw material;
- Reduced hazardous substances, in particular metal components.

The social improvements achieved included improved health and safety relating in particular to air quality due to the reduction of hazardous substances used in the product.

As a result of these improvements, the product was quicker and more cost effective to manufacture resulting in substantial cost savings and competitive advantage for the company and their customers.

6.0 CASE 6: HEATED WATER TANKS

Sector	Plastics
Case Description	SPSD application to existing product
Offering Developed	Heated water tanks for industry applications
Initiating Company (Size, Supply Chain Role & customer)	SME, OEM Commercial industrial customers (various sectors)
Involved companies (Size and Supply Chain Roles)	3 x raw material suppliers (SME & large) 1 x SME component assembler
Team	
Initiating Company	MD, Project Manager, Product Designer, Production Engineer, Purchasing Manager, Financial Controller
External to Initiating Company	Raw material suppliers, 2 x commercial customers, SPSD Mentor, Environmental Consultant
Existing sustainability related culture in initiating company	No
Management Systems e.g. Quality, Environment etc..	ISO 9002 Health & Safety
Existing Product Development systems	Yes
Drivers	Potential new market opportunities
Sustainability Impacts	
Environmental Impact	Improved energy efficiency of heating units in operation Reduced raw material usage through redesign
Social Impact	Unchanged
Economic Impact	Cost savings identified in production and for end user through energy savings
Commercially viable	Yes, in operation

Other impacts	Improved supplier and customer relationships Capability building via increased knowledge and skills
SPSD Implementation Stages	As per draft SPSD guide
Supporting tools used	Abridged LCA using LCA Workbench Irish software tool
Supply chain organisation locations	Poland, UK, Ireland
Importance of sustainability benefits to marketing/brand	Potentially important to marketing in Northern European markets
Third party validations achieved (e.g. ecolabels)	None
Follow up application to other products and/or services	Incorporation into product and/or service development process on an ongoing basis
Interviewee	Initiating Company , Project Manager (R&D Manager)

Case Summary

The OEM in this case manufactures water tanks for the industrial sector with exports to overall 30 countries worldwide. SPSD was applied to an existing heated, insulated water tank exported for use in cold climates to develop a more sustainable option. The environmental improvements of the new insulated heating tank include:-

- **Significantly improved energy efficiency of heating units in operation;**
- **Dematerialization through reduced raw material usage;**
- **Choice of raw materials to facilitate disassembly, reuse and recycling at end of life.**

The social impacts were unchanged. Eco-efficiencies resulted in a cost saving for the production of new product for the OEM and reduced energy costs for the customer due to the significant energy efficiency of the new tanks in operation.

7.0 CASE 7 REUSABLE PACKAGING

Sector	Packaging
Case Description	SPSD on new concept
Offering Developed	Reusable, returnable packaging for micro electronics
Initiating Company (Size, Supply Chain Role & customer)	SME, OEM Commercial electronics component manufacturers and OEMs
Involved companies (Size and Supply Chain Roles)	4 x raw material suppliers (SME) 1 x mould tooling contractor

Team	
Initiating Company	MD, Project Manager, Product Designer, Production, Financial Controller
External to Initiating Company	Raw material suppliers, SPSD Mentor, Environmental Consultant
Existing sustainability related culture in initiating company	No
Management Systems e.g. Quality, Environment etc..	Health & Safety
Existing Product Development systems	Yes
Drivers	Packaging & packaging waste directive
Sustainability Impacts	
Environmental Impact	Reduced material usage and waste generation due to extended life of this returnable, reusable packaging vs. previous non reusable version; Reduced hazardous substances; Design facilitates eventual end of life reuse/recycling as it is one material type and with components designed to join without the use of adhesives.
Social Impact	Unchanged
Economic Impact	Increased production costs; Unit cost to customer increased, but reduction in the number of units required due to reusability results in a significant overall cost saving for customers.
Commercially viable	Yes, in operation
Other impacts	Improved supplier and customer relationships Capability building via increased knowledge and skills
SPSD Implementation Stages	As per draft SPSD guide
Supporting tools used	None
Supply chain organisation locations	UK, Ireland
Importance of sustainability benefits to marketing/brand	Yes
Third party validations achieved (e.g. ecolabels)	None
Follow up application to other products and/or services	Incorporation into product and/or service development process on an ongoing basis
Interviewee	Initiating Company , Project Manager (Product Development Operations Manager)

Case Summary

In this case SPSD was used to develop a reusable returnable packaging system for micro electronics components. The traditional packaging for their existing customers micro electronics to be replaced was cardboard boxes with expanded polystyrene inserts which were not functionally suitable or economically feasible for return and reuse. Hence significant volumes of waste cardboard and polystyrene were generated from this packaging option and the aim was to eliminate this and provide a more sustainable packaging alternative. The result was reusable, returnable, durable low cost, plastic packaging units designed to flat pack and stack following use to facilitate return. This stackable feature significantly reduces the volume making it cost effective to return for reuse. Overall the environmental benefits include:-

- Reduced material usage and waste generation due to the extended life of this returnable, reusable packaging vs. previous non reusable product;
- Reduced material usage and increased end of life reuse/recycling options as the packaging is made of one recyclable plastic material (the components are moulded and designed to join without the use of adhesives etc.);
- Reduced energy usage in production.

The social impacts were unchanged.

The functionality of the packaging was improved due to increased durability and an innovative modular tooling process was developed to increase packaging sizes and types more cost effectively. Further the stackable nature of the packaging facilitated cost effective return for reuse. Overall, the unit cost per packaging was increased but the reduction in the number of units required due to reusability results in a significant overall cost saving for customers.

8.0 CASE 8: WASTE TIMBER RECOVERY AND ORNAMENTAL SOIL IMPROVER PSS

Sector	Timber
Case Description	SPSD on new concept
Offering Developed	PSS to include collection of wood waste and manufacture of ornamental wood chip soil improver
Initiating Company (Size, Supply Chain Role & customer)	SME, OEM Domestic & commercial
Involved companies (Size and Supply Chain Roles)	SME, OEM; 6 x raw material suppliers (SME)
Team	
Initiating Company	General Manager, Project Manager, Environment Engineer, Purchasing Manager, Financial Controller & Sales/Marketing advisor

External to Initiating Company	Raw material suppliers, SPSD Mentor, Environmental Consultant
Existing sustainability related culture in initiating company	Yes, no formal systems
Management Systems e.g. Quality, Environment etc..	Health & Safety
Existing Product Development systems	Yes
Drivers	Increasing market for wood waste recovery
Sustainability Impacts	
Environmental Impact	Reduced waste to landfill by recovery of wood waste for reuse; Eliminated virgin timber raw material usage; Reduced waste due to recyclable packaging for product.
Social Impact	Unchanged
Commercial Impact	Increased investment costs to provide this new PSS; Increased profitability for OEM from waste recovery services and sales of new soil improver product; Cost of soil improver product is comparable with existing competing soil improver products on the market.
Other impacts	Improved supplier and customer relationships; Capability building via increased knowledge and skills; Industry award – best new product, gardening sector
SPSD Implementation Stages	As per draft SPSD guide
Supporting tools used	Abridged LCA
Supply chain organisation locations	USA, Ireland, Northern Ireland
Importance of sustainability benefits to marketing/brand	Very important
Third party validations achieved (e.g. ecolabels)	EU Eco label (soil improvers) under consideration
Follow up application to other products and/or services	Incorporation into product and/or service development process on an ongoing basis
Interviewee	Initiating Company , Project Manager (Environment Engineer)

Case Summary

In this case, the OEM, a timber sawmill, applied SPSD to develop a new concept soil improver. A PSS to include collection of wood waste and manufacture of a wood mulch soil improver in recyclable packaging was the result. The main environmental benefits of the PSS include:-

- Reduction in waste to landfill as the wood waste was diverted from landfill which was where it had been previously disposed of.
- Reduction in waste due to selling in bulk without packaging where possible (commercial customers) and recyclable polyethylene packaging for domestic customers.

Many options for the recovery / reuse/recycling of the wood waste were considered e.g. energy recovery, as a raw material in the manufacture of timber products etc. As energy recovery was already at capacity from the OEM's customer base and the wood waste was surplus, a permitted facility was set up to collect, segregate and recover uncontaminated waste for use as an ornamental soil improver. Extensive testing was conducted to ensure no adverse environmental impacts were resultant and that the functionality of the waste material was suitable. This was the case.
No social benefits were identified.

Economically, the cost of the soil improver is comparable with existing products. The OEM have increased their markets and profitability from the waste recovery services and sales of new soil improver product.

9.0 CASE 9: MEDICAL DEVICE PACKAGING

Sector	Healthcare
Case Description	SPSD application to existing product
Offering Developed	Medical device packaging
Initiating Company (Size, Supply Chain Role & customer)	Large, OEM Hospitals, healthcare practices
Involved companies (Size and Supply Chain Roles)	8 x raw material suppliers (SME & large)
Team	
Initiating Company	CEO, Project Manager, R&D Manager, Product design team, Environment Manager, Purchasing Manager, Financial Controller
External to Initiating Company	Raw material suppliers, healthcare customers, SPSD Mentor, Environmental Consultant, medical regulators

Existing sustainability related culture in initiating company	Yes, ISO14001 EMS
Management Systems e.g. Quality, Environment etc..	ISO14001 ISO 9001 Health & Safety
Existing Product Development systems	Yes
Drivers	Increasing costs of waste disposal for packaging
Sustainability Impacts	
Environmental Impact	Dematerialisation and waste reduction by elimination of instruction/contacts information sheets (printed in seven languages for exports to different countries) and replacement with a pictorial diagram & contact details on the packaging; Dematerialisation and waste reduction by reducing the volume of raw materials to one material type and reducing the size of the packaging; Eliminated hazardous substance usage by eliminating adhesive.
Social Impact	Easier usage of offering for end user Less hazardous materials hence improved health and safety in production.
Commercial Impact	Significant cost savings identified
Other impacts	Improved functionality for user Significant competitive advantage Improved supplier and customer relationships Capability building via increased knowledge and skills
SPSD Implementation Stages	As per draft SPSD guide
Supporting tools used	Abridged LCA
Supply chain organisation locations	UK, Ireland, USA,Germany
Importance of sustainability benefits to marketing/brand	Yes
Third party validations achieved (e.g. ecolabels)	None
Follow up application to other products and/or services	Incorporation into product and/or service development process on an ongoing basis
Interviewee	Initiating Company , Project Manager (R&D Manager)

Case Summary

This case applied SPSD to the existing packaging and user instructions for a medical device. The result was a new packaging approach with improved sustainability performance and functionality in comparison to the previous packaging. The environmental benefits include:-

- Dematerialisation and waste reduction by elimination of instruction/contacts information sheets (printed in several languages for export to different countries) and replacement with a pictorial diagram & contact details on the packaging;
- Dematerialisation and waste reduction by reducing the volume of raw materials to one material type and reducing the size of the packaging;
- Eliminated hazardous substance usage by eliminating adhesives through an alternative packaging sealing process not requiring adhesives.

This case is a good example of how questioning the functional requirement can result in substantial environmental and social benefit. In this case, considering the best way to provide information dissemination to users (rather than manufacturing a paper instruction leaflet) resulted in the elimination of significant paper usage (to provide paper inserts in a range of languages) and replacement by a pictorial diagram on the packaging itself.

The social impacts were a better functionality from healthcare user with users finding the pictorial instructions superior to the previous packaging insert text and facilitating appropriate usage of the device. The elimination of adhesive improved the production health and safety in terms of material handling and air quality.

In terms of economics, significant cost savings were identified largely from the dematerialisation aspects of the new packaging.

10.0 CASE 10: COMMERCIAL SEATING

Sector	Furniture
Case Description	SPSD on new concepts
Offering Developed	Stackable commercial seating
Initiating Company (Size, Supply Chain Role & customer)	SME, OEM Commercial customers in a diversity of sectors e.g. transport, entertainment)
Involved companies (Size and Supply Chain Roles)	3 x raw material suppliers (SME & large), selection of existing end customers
Team	
Initiating Company	MD, Project Manager, Product designer, Purchasing, Sales & Financial Manager

External to Initiating Company	Raw material suppliers, selection of end customers, SPSD Mentor, Environmental Consultant, business consultant
Existing sustainability related culture in initiating company	None
Management Systems e.g. Quality, Environment etc..	Health & Safety
Existing Product Development systems	Yes
Drivers	New market niche
Sustainability Impacts	
Environmental Impact	Reduced virgin timber usage by utilizing a production waste as a raw material; Reduced waste generation; Reduced hazardous substances usage; Shift to sustainably managed timber resources
Social Impact	Less hazardous materials hence improved health and safety in production and for users
Commercial Impact	Significant cost benefit identified
Other impacts	Improved supplier and customer relationships Capability building via increased knowledge and skills
SPSD Implementation Stages	As per draft SPSD guide
Supporting tools used	None
Supply chain organisation locations	USA, Ireland
Importance of sustainability benefits to marketing/brand	Increasing important to end customer – especially regarding sustainability of timber sourcing
Third party validations achieved (e.g. ecolabels)	None
Follow up application to other products and/or services	Incorporation into product and/or service development process on an ongoing basis
Interviewee	Initiating Company , Project Manager (General Manager)

Case Summary

In this case, a new stackable commercial seating product was developed to meet a new perceived market need by the OEM. The OEM in this case manufacture high quality timber furniture. Waste timber and saw dust from the production facility were either disposed of to landfill or burned to generate energy to power the facility. Also, high quality waste timber was being generated from the production. The high quality waste timber generated from the

main production was successfully utilized as raw material for the new timber chair offering developed. The main environmental benefits include:-

- Reduced virgin timber usage by utilizing a production waste as a raw material;
- Reduced waste generation and disposal to landfill;
- Reduced hazardous substances usage by eliminating the need for adhesives (through redesign of the components and joining mechanism to eliminate the requirement for adhesives) and use of water based varnishes;
- Supporting sustainable timber growth and supply by switching to timber suppliers holding Forestry Stewardship Council (FSC) certification.

The social benefits resulting include improved health and safety in production particularly relating to materials handling and air quality due to the elimination of adhesives and switch to water based varnishes.

Economically, the new chair is highly cost competitive largely as the raw material costs are so low. It is already generating profit as a new product range for the OEM.

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