

# Chapter 2

## Situation Analysis

In the previous chapter, some definitions and examples of the concept of sustainability and probable trends in environmental matters and regulations were presented. Chapter 2 will serve as a framework to help analyze a company's current situation and identify strengths and weaknesses. The result of this situation analysis will be the basis for the strategy development in Chapter 3.

The situation analysis will follow the logic model of (i) corporate, (ii) market, (iii) product, (iv) production, and (v) management. The checklists at the end of each section are designed to help a company undertake its own analysis.

At the end of this chapter, one should have a much better understanding of the potential business effects of sustainability.

### 2.1 Corporate Analysis

The first section of this chapter on Situation Analysis examines the overall sustainability of a company at the corporate level. At this level, decisions influencing the entire company are made, in particular those that relate to corporate direction and major investment. Thus, it is important to define the boundaries within which environmental improvements are possible.

If no strategic direction is provided nor commitment made to move towards sustainability through, for example, ecoproduct development, there can be only limited scope and freedom for related decisions by managers responsible for marketing, product development and/or manufacturing. But, if environmental initiative is taken and support provided by corporate management, ecoproduct development can become an important driver for environmental progress and competitive market advantage.

As a first step, a series of questions are asked in order to determine the current environmental status of the company. This should help prepare corporate-level management for related strategy development and decision making in [Section 3.1](#).

### ***Organization and corporate culture***

First and foremost, the code of conduct of the company should be examined:

- Has a code of conduct already been developed?
- If so, does it include the concept of sustainability?
- To what degree does the company's actual behaviour reflect the code of conduct?
- What yet needs to be done to ensure that behaviour reflects the code of conduct statement?

The existence of an environmental management system and the way of organizing and evaluating processes (design and manufacturing processes, responsibilities) should be analyzed next. Is a review and audit plan of environmental management available? Is an assessment of potential environmental risks along the value chain available?

### ***Production***

For production, it is important to understand whether core processes are clearly defined and how the manufacturing processes are structured. What efforts have been made to increase energy and resource-use efficiency in the various manufacturing stages? Has ISO 14001 or an Eco-Management and Audit Scheme (EMAS) been introduced in the company?

Does the company manufacture the main components of its products itself or are they purchased from external suppliers? What is the in-house core competence?

### ***Product***

Is Ecodesign part of the management system?

For the company's products, it is important to know their environmental performance. Are Life Cycle Assessment (LCA) results for products available? Are product and production related environmental data available?

How much effort has been put into significantly improving the energy and resource efficiency of the products? How well is the product performing when compared with the best available technologies?

Benchmarking the company's products against competing products helps to understand the key environmental performance indicators such as:

- Level of energy consumption
- Level of material consumption
- Degree of modularity
- Relative content of renewable materials
- Number of reusable parts and components
- Recycling rates
- Toxicity of components and perhaps of the whole product

Benchmarking serves to identify and quantify the degree of innovation potential available for the product.

**Supply chain and logistics**

Integrating suppliers, as well as managing and improving the relationship with them, are important initiatives in ensuring the supply chain remains robust. As such, it is important to know if auditing programs for suppliers are in place and whether these also include the social aspects of sustainability? Are green purchasing guidelines available?

Where are the suppliers located and how is transportation organized?

**Communication**

The external perception of any company depends, to a large extent, on its attitude towards outreach and communication. Several relevant reporting mechanisms have been developed and are available to support the kind of corporate image a responsible company may seek. Has the company made a commitment toward public reporting on corporate sustainability and has a Corporate Social Responsibility (CSR) report been made available?

Are other forms of environmental reporting and environmental communication available – especially those about products? Is the process of development of Environmental Product Declaration (EPD) common practice for all of the company’s new products?

**Staff**

The concept of sustainability developed at the corporate level should be implemented and “lived” by all staff members. Therefore, responsibility for all parts of the product life cycle/value chain needs to be assigned – who will be the lead agents for the different environmental issues?

Additionally, regular awareness training on environmental and sustainability issues are valuable.

With the following checklist, the current status of the company at the corporate level can be determined, potential weak points identified for follow-up, and references made to corresponding chapters.

Checklist for corporate analysis

Assessment questions	Answer	Comments	Recommended follow-up activities	Related sections
Do you have an environmental management system in place?	Yes ☺ No ☹	ISO 14001, EMAS	International extension	2.4, 3.5
Is Ecodesign already included in a management system?	Yes ☺ No ☹	IEC 62430, Ecodesign directive Annex IV/V, ISO 9001 or ISO 14001, integrated management system	Review	2.3, 3.5

(continued)

Checklist for corporate analysis (continued)

Assessment questions	Answer	Comments	Recommended follow-up activities	Related sections
Are the missing environmental processes identified and installation planned?	Yes ☺	Energy, recycling, communication, chemicals, software	Continuous extension	2.3, 2.4, 3.5
	No ☹			
Are the missing environmental tools identified and application planned?	Yes ☺	LCA, EPD, design rules, product carbon footprint (PCF), environmental quality function deployment (EQFD)	Extension	2.3, 3.3
	No ☹			
Are environmental responsibilities checked at all levels and are responsible persons assigned?	Yes ☺	Responsibility at the management level to determine level of expert assistance required	Responsibilities for new processes	2.3, 2.4, 3.5
	No ☹			
Is a document available describing all environmental tasks, responsibilities, and processes?	Yes ☺	Environmental principles are also a guide for customers and public	Annual check of validity	2.3, 2.4, 3.5
	No ☹			
Is quality management involved in checking environmental attributes of components, materials, and products?	Yes ☺	Incoming tests required, specifications required, integration in software systems, contracts required	Update regularly	1.2, 2.3, 2.4, 3.5
	No ☹			
Have sources been identified for systematic information about trends in legislation and new standards?	Yes ☺	Sources could be associations, consultants, government web sites	Continuous participation	1.2
	No ☹			
Has risk management been installed for dealing with environmental risks?	Yes ☺	Includes trend analysis of legislation, standards, competition	Annual update	1.2, 2.3, 2.4, 3.5
	No ☹			
Is an early-warning system in place to (a) identify environmental problems with components or materials in time and (b) to inform management?	Yes ☺	Problems can come from suppliers and public media. Authorized persons must be available to manage crises	Test system	1.2, 3.5
	No ☹			

## 2.2 Market Analysis

Corporate environmental stewardship is one of a few key trends shaping the business world of the future. Led by mainstream Fortune 500 companies, corporate environmental management is good business. It enhances share value and

market penetration. It will require tools, some of which are already available on the market, such as Ecodesign. This wave of environmental protection is a key trend for tomorrow's business.

Evidence of this trend includes:

- The development of the Dow Jones Sustainability Group Index (DJSGI) which tracks roughly 225 companies that are considered leaders in their sectors in sustainable practices and operations. Notwithstanding the recent volatility of the markets, the DJSGI has outpaced the performance of comparable equity indices such as the Dow Jones Global Index.
- The firms identified by DJSGI are far from being considered peripheral players in the global economy. Rather, the firms identified as leading the global shift toward corporate environmental stewardship and sustainability include mainstream performers such as BMW, Bristol-Myers Squibb Co., Dofasco Inc., Fujitsu Ltd., Procter & Gamble Co., Dow Chemical Co., Siemens, Philips, and Unilever N.V. All are mainstream organizations that have targeted sustainability as core success values for the future.
- In a Harvard Business Review article, W. Chan Kim (Boston Consulting Group) and Renee Mauborgne (INSEAD Distinguished Fellow) described "environment friendliness" as one of the "six levers" for effective and foresighted business planning in the twenty-first century (the others were more traditional: customer productivity, simplicity, convenience, risk mitigation, and fun and image) [1].
- When the Global Environmental Management Initiative (an NGO of Fortune 500 companies) interviewed 30 leading multinationals (mainstream companies like Canon, Compaq, Motorola, Weyerhaeuser, GM, and Du Pont), it found that all had environmental management systems of some shape, and that all included environmental procurement as part of that system.
- Heinz recently acquired Earth's Best Baby Foods in order to access the environmental market demographic. For the same purpose, Colgate-Palmolive acquired Murphy's Oil Soaps. Similarly, recognizing the market opportunity for environmental services, Price-Waterhouse Coopers recently bought EcoBalance, a global environmental consulting practice.

None of this corporate initiative is about environmental altruism alone. It's about how today's most foresighted companies are sowing the seeds for commercial success in the future. There is no current dispute: corporate sustainability and prolonged shareholder value is based, in part, on environmental stewardship. This is one of the waves shaping the business world of the next 25 years.

In any assessment of the marketplace, a number of considerations warrant examination. The most fundamental are (i) the nature of the product itself and (ii) the sector of the market in which that product operates (including the views and perspectives of the customers of that sector of products).

More specifically:

- (i) From a product perspective, there are some useful questions to think about when considering how to proceed:

- From your customers' perspective, is the product purchased on its own merits or the services the product provides? For example, an automobile provides transportation for people, but is most often purchased for a wide range of unrelated reasons – status, power, colour – to name a few. This question becomes important when developing a marketing strategy.
  - What are your customers' environmental sensitivities or attitudes to your product category? For example, people often think of recycled content when discussing paper products and many will think about the potential health impacts of cleaning chemicals. Similarly, most products which consume energy in the use stage of their life cycle, will create concerns about the costs of energy consumption and perhaps even those impacts related to climate change. These customer concerns may be driven by internal factors, or by outside factors related to export markets or other market pressures. In any case, customers expect that suppliers actually think in advance, thus helping them (the customers) avoid potential problems.
- (ii) From a market sector perspective, there are similarly some useful questions to review as part of any analysis:
- What is the size and level of competition in the market sector in which you operate?
  - To what degree is your market sector segmented? A sector can have multiple segments as well as different types of customers, all of which behave in different ways. For example, in the cleaning products sector, there are many different types of cleaning products available, and also a variety of end-consumers. Those could relate to individual households, institutional cleaning (janitorial) companies, or commercial/industrial operations.
  - What are the environmental trends acting upon or influencing your market sector and what is the prognosis for those trends in terms of future directions and strength? The trends may relate to a variety of factors:
    - (a) Governmental directives and regulations such as the European Union directives on Ecodesign and RoHS
    - (b) Consumer concerns over toxic chemicals or food safety, or
    - (c) Environmental campaigns about specific issues, such as forest management or climate change
  - How many companies are competing in your market sector, and how many of them are already active in the area of environmental marketing?
  - If your competitors have been active in using environment in their marketing efforts, what types of environmental messaging approaches are they using, and to what degree have their efforts been well received by their customers and the general public?
  - Given the current environmental issues acting on your product sector, to what degree should you be prepared to consider all of the environmental impacts of your product over its life cycle? This should relate to the strength of the current environmental trends and the likelihood of customer questions or demands that go beyond the environmental issues currently being addressed.

- What are the most effective channels, vehicles, and information systems available to best position your product from a performance and environmental perspective? Section 4.2 will help identify and explain the options available and which might be best suited.

Answering these questions will be helpful in determining what type of environmental communication to use and how best to position your product.

Checklist for market analysis

Assessment questions	Answer	Comments	Recommended follow-up activities	Related sections
Do your customers show interest in environmental/sustainability issues yet?	Yes ☺	If yes, there is opportunity. If no, you will need to be prepared to communicate your product's environmental attributes soon	Conduct market analysis	3.2, 4.2
	No ☹		Prepare framework of your environmental/sustainability communication	
Do your competitors use environment in their marketing?	Yes ☺	If no, there is opportunity to lead. If yes, you will need to consider your options	Develop plan for own environmental communication	1.1, 1.3, 2.3
	No ☹			
Are you able to effectively communicate the environmental benefits of your products yet?	Yes ☺	Evaluate the environmental impacts of the key life cycle stages and key environmental performance indicators of your products	Determine the environmental profile of your products and examine communication options	1.1, 3.2, 4.2
	No ☹			
Do you currently use environmental communications in your marketing?	Yes ☺	If yes, make sure your claims are correct, trustworthy and reliable. If no, use it as an opportunity	Evaluate your current environmental communication and marketing and extend it with a product perspective	4.2
	No ☹			

### 2.3 Product Analysis

The development of any ecoproduct will require focus on four major aspects: (i) environmental, (ii) resource use efficiency, (iii) degree of environmental hazard, and (iv) the degree of extended material utilization.

In assessing the environmental aspects, consideration of product and stakeholder requirements are necessary. Analysis of the efficiency of resource use will require

an analysis of the possibilities for, and ease of, recycling. The aspects related to environmental hazards will require an examination of all of the critical substances, with special attention given to the toxicity of materials and components. The extended material utilization aspects will require analysis of the potential to use recycled and more eco-friendly materials.

### ***2.3.1 Environmental Aspects***

Environmental aspects can be defined as elements of the processes, parts, materials, or activities of a product that have the potential to interact with the environment. In this sense, interaction refers to the use of input resources, the generation of emissions and any products, by-products, or co-products that become outputs. Environmental aspects are, by definition, broad in scope. As such they are not quantifiable. However, environmental parameters, relating to the environmental aspects, are quantifiable. Examples of environmental parameters include:

- The type and quantity of materials used (weight, volume)
- Power consumption
- Emissions
- Rate of recyclability
- The time required for disassembly

A more exhaustive list of such parameters can be found in the references [2].

The IEC defined environmental parameters as “quantifiable attributes of an environmental aspect” [3]. Thus, any one environmental aspect can be understood as a collection or category of environmental parameters. For instance, emissions to the atmosphere would be considered to be an environmental aspect, while specific emissions (e.g. CO<sub>2</sub>, NO<sub>x</sub>) would be considered to be environmental parameters.

Ecodesign aims at improving the environmental performance of a product by reducing the environmental impact of significant environmental parameters. Thus, the presence or absence of significant environmental parameters can be used as indicators for the evaluation of the environmental performance of a product.

The analysis of the environmental aspects of a product should be approached from two different perspectives: (i) the product life cycle and (ii) stakeholder requirements. The former can be envisaged as those environmental aspects that are internal to the manufacturer of a product, while the latter as those aspects that are external to the manufacturer. The analysis of the product life cycle is the identification of significant environmental aspects and thus significant environmental parameters of a product throughout its entire life cycle. The analysis of stakeholder requirements includes the identification of significant environmental parameters from the various external pressures on the product and its manufacturer, such as legal requirements, ecolabelling criteria, and competitors’ product performances.



Once a product has been chosen for the environmental improvement process, the product will need to be clearly described in terms of environmental parameters. The purpose of describing a product this way is twofold: (1) to define the reference point, or starting point, in order that improvements resulting from the Ecodesign can be identified; and (2) to identify the significant environmental parameters which are targeted for improvement.

Next, a system boundary of the product system should be defined. This is termed product modeling. The product system boundary encompasses all of the life cycle stages of the product. In each life cycle stage, relevant values of the pre-selected environmental parameters are determined.

The environmental aspects of the product life cycle can then be analyzed by using either a Life Cycle Thinking (LCT) matrix tool or Life Cycle Assessment (LCA) tool, depending on the needs of the user. The environmental aspects of the stakeholder requirements can be analyzed using such tools as Environmental Quality Function Deployment (EQFD) or Environmental Benchmarking (EBM). The significant environmental parameters can be identified from both analyses [2].

### 2.3.1.1 Analysis of the Product Life Cycle

Life cycle thinking implies consideration of all relevant environmental aspects of a product in its entire life cycle. The aim of the analysis is to identify significant environmental parameters of a product. Here, due attention should be paid to consider all relevant life cycle stages.

There are various analytical tools available. Most well known are LCA and the matrix tools such as the LCT matrix, among others. The former is a comprehensive tool. However, it takes much effort and time to implement. The latter is simple to use but it lacks rigour in analysis.

The LCT matrix tool is described in the Ecodesign standard of electrical and electronic products, IEC 62430 [3]. The method consists of columns and rows, where lifecycle stages and environmental aspects are listed, respectively. For a cell where the relevant life cycle stage and environmental aspects meet, relevant environmental parameters with their values are recorded. Table 2.1 shows an example of an LCT matrix used in the LCT matrix tool [28].

Once all of the relevant environmental parameters with values are collected and the cells of the matrix filled in, their values need to be converted into values with common units such as CO<sub>2</sub> equivalents. The purpose of the conversion is to calculate the relative contribution of each environmental parameter to the product system. This calculation can only be made when all values of the environmental parameters in the LCT matrix are expressed in the same units. The conversion simply involves the multiplication of the environmental parameter values in each cell by the corresponding CO<sub>2</sub> equivalents. Dividing the CO<sub>2</sub> equivalent value of each environmental parameter by the total CO<sub>2</sub> equivalent value of the product, gives the relative contribution of

**Table 2.1** Life cycle thinking matrix

Life cycle →	Use of raw materials	Manufacturing	Distribution	End of Use life
Environmental aspect↓				
Raw material and energy consumption				
Emissions to air, water and soil				
Physical pollution				
Waste material				
Reuse, recycling, and recovery of material and energy				
Total				

each environmental parameter. By comparing the magnitude of each parameter's relative contribution, the significant environmental parameters can be identified. Similarly, the most significant environmental aspects and life cycle stages can also be identified.

The analysis of the product life cycle by LCA has already been well documented [2]. As such, the use of an LCA tool for the identification of significant environmental parameters is not discussed here. Although the LCA tool is different in depth and breadth from the LCT matrix tool, the outcome remains largely the same. In the case of LCA, however, a more complete ecological profile (cf. [Section 5.3](#)) of a product can be generated so that, for example, the carbon footprint of the product can be more readily obtained.

### Alert

LCA data can only be compared globally if they are measured with the same physical units. Local or regional data should only be compared on a local or regional level. Only scientifically world-wide accepted impact categories should be used, such as “global warming” or “ozone depletion”. Many impact categories used today are not in accordance with ISO 14040. In addition, the weighting of impacts of a product often results in summaries of non-comparable effects. Such results should be evaluated with extreme care.

### 2.3.1.2 Analysis of Stakeholder Requirements

Stakeholder requirements include the needs of:

- (i) The end users
- (ii) The business to business (B2B) customers

- (iii) Environmental directives and regulations
- (iv) Eco-labels (voluntary product criteria to achieve certification)
- (v) Standards (general/procedural requirements to fulfil)
- (vi) Competitors (environmental parameters or features to compete against)

These stakeholder requirements must be converted into measurable parameters, or environmental parameters for consideration in product design. Commonly used tools are EQFD and EBM.

Significant environmental parameters can be identified by using EQFD [2].

EQFD considers the various stakeholder requirements listed above. It can be implemented in the five steps shown in Table 2.2.

Significant environmental parameters can also be identified using EBM [2]. EBM is a modification of the conventional benchmarking tool that allows the identification of any environmentally weak points of a product in comparison with other products. A relative score ranging from 1 to 5 is assigned to each environmental parameter (very good: 5, good: 4, average: 3, bad: 2, very bad: 1). A gap analysis between the reference product and other products results in the identification of the most significant environmental parameters.

The focus for environmental performance improvement through Ecodesign is the most significant of environmental parameters. In the Ecodesign process, product designers develop performance specifications and functions based on the significant environmental parameters and then seek ways to reduce the impact from those parameters. The product analysis generates the environmental profile of the product.

An “Environmental Profile” is a description of the inputs and outputs (such as materials, emissions, and waste associated with a product throughout its life cycle) deemed environmentally significant. They are expressed in physical quantities that can be measured. Simply put, the ecological profile of a product contains metrics of the significant life cycle based environmental parameters. It provides current information on a product with respect to its impact on the environment. An example is shown in Section 5.3 in the form of a carbon footprint.

**Table 2.2** Steps and activities for the implementation of EQFD

Step	Activity
1	Identify the stakeholders requirements and translate them into the environmental voice of the customer (EVOC)
2	Assign a relative weight to EVOC with a scale from 0 to 10
3	Define the relationship matrix between EVOC and environmental parameters with the relationship factor blank (no relationship), 1 (weak relationship), 3 (medium relationship), 9 (strong relationship)
4	Each environmental parameter is multiplied by the relationship factor and summed up for all environmental parameters
5	A relative importance is generated from step 4; from this result, significant environmental parameters are identified

The ecological profile can be used to communicate the environmental performance of a product to the marketplace. There can be a variety of communication tools based on the ecological profile such as environmental product declarations and ecolabelling. Of the various communication tools, the carbon footprint has been considered one of the most appealing in today's market because of society's concern about global warming.

### 2.3.1.3 Product Carbon Footprint and Management

The "Carbon Footprint" originates from the "Ecological Footprint", although the two differ in concept. The ecological footprint is based on the assumption that every category of energy and material consumption and waste discharge requires the productive or absorptive capacity of a finite area of land or water. By summing up the land requirements for all categories of consumption and waste discharge by a defined population, the total area represents the ecological footprint of that population on the Earth. In short, the ecological footprint measures land area required per person, rather than population per land area [4].

On the other hand, the carbon footprint is not really a footprint as originally defined by the ecological footprint. Rather, the carbon footprint is the carbon profile of a product that identifies the total amount of emissions of greenhouse gases (GHG) including carbon dioxide (CO<sub>2</sub>), methane, etc., associated with a product over its entire life cycle. Often the term "Product Carbon Footprint" or PCF is used in lieu of carbon footprint. When data collection is limited to GHG emissions in a LCA, then the totality of the LCA results of the product becomes the carbon footprint of the product or PCF. The carbon footprint, therefore, is a sub-set of the data gathered during the LCA implementation.

There are several approaches in collecting and calculating the GHG emissions of an organization, operational facility, and product leading to the identification of the reduction opportunities and development of a carbon footprint [5]. They are the IPCC Guideline [6], The Green House Gas Protocol [7], ISO 14064 [8], BSI PAS 2050 [10] and ISO/WD 14067 [11]. The first three are for the organization/operational facility and the last two for products.

The IPCC Guideline is an international guide for the calculation of GHG emissions from various emission sources. It sets up criteria for major emission sources in various industries and defines equations for the calculation of GHG emissions from the sources as well as emission factors. The primary use of this guideline is for the development of the GHG emission inventory data of nations, organizations, and operational facilities.

The GHG Protocol offers principles and standardized procedures for the calculation of GHG emissions of an organization [7]. In particular, the GHG Protocol classified GHG emissions based on emission types and sources into scopes 1, 2 and 3. A scope 1 emission is a direct emission from the organization and operational facilities, a scope 2 emission is an indirect emission due to the electricity consumption, and scope 3 emissions include all indirect emissions other than scope 2, including

emissions from the supply chain. The calculated GHG emissions thus should be reported in terms of scopes 1, 2 and 3, where scope 3 is an optional element.

The ISO 14064 standard, although international in nature, is less practical in calculating GHG emissions for companies compared with that of the GHG Protocol and less specific in criteria for emission sources compared with that of the IPCC Guideline. Thus, it is not used widely by industry.

BSI PAS 2050 [10], is a guide for the calculation of GHG emissions of a product and service, not organization or operational facility. It is based on the principles and methods of LCA, in particular, ISO 14040 and 14044. It also incorporates in the methods of the GHG Protocol and the IPCC Guidelines. However, it does not provide specific methods and equations for the calculation of GHG emissions. Thus, it is necessary to use the IPCC Guideline method for the development of the GHG emission inventory data from various emission sources.

ISO 14067 working draft [11] is being developed to be an international standard for quantifying carbon footprint of a product and service in its part 1 document, while part 2 is for communication of the quantified carbon footprint to the market. The quantification method is based on LCA, in particular ISO 14040 and 14044, and intends to incorporate salient features of existing GHG emissions methods including all the Guideline, Protocol, and standards discussed above. Since it is in the developmental stage, no definitive methods are available from this working draft yet.

A method for the quantification of the carbon footprint of a product can be proposed in which the salient features of the existing methods are combined. This proposed method is based on two different approaches, i.e. GHG emissions data collection at the organizational level and product level. The methods of the IPCC Guideline and the GHG Protocol were used for the GHG emissions data collection at the operational level. The methods of BSI PAS 2050 [10] and ISO 14067 working draft were used for the GHG emissions data collection over the entire life cycle at the product level. The latter follows the conventional LCA approach in collecting data. Operational and product levels have different degrees of details in the data collection.

### **Alert**

#### *Operational Level:*

Normally only scope 1 GHG emissions are collected here. No serious consideration is given to scope 2 and 3 emissions. In depth analysis of the scope 1 process enables the operation and/or organization to use the GHG emissions data for accounting and certification of the GHG emissions.

#### *Product Level:*

Collection of the GHG emissions data of a product follows the conventional LCA approach based on life cycle thinking of the product. The degree of detail of the GHG inventory in the manufacturing stage of the product is not detailed enough to be used for the GHG accounting and certification. The degree of details of the GHG inventory data for scopes 1, 2 and 3 is the same.

**Table 2.3** GWP of typical GHGs [12]

Species	Chemical formula	GWP <sub>100</sub>
Carbon dioxide	CO <sub>2</sub>	1
Methane	CH <sub>4</sub>	25
Nitrous oxide	N <sub>2</sub> O	298
Hydrofluoro carbons (HFCs)	–	124–14.800
Sulfur hexafluoride	SF <sub>6</sub>	22.800
Perfluoro carbons (PFCs)	–	7.390–12.200

The collection and calculation of the GHG emissions data of a product consists of two parts; product modelling and calculation of the GHG emissions. Product normally includes packaging and the unit of the GHG emissions is kg CO<sub>2</sub> equivalent (eq). The basis for the equivalency is 100-year global warming potential (GWP). Table 2.3 shows GWP values of typical GHGs.

The outcome of the data collection includes: (i) the GHG inventory of the product manufacturing stage including key parts and unit manufacturing processes, and (ii) the opportunities for improvement of the GHG emissions along the supply chain of the product. The identified improvement opportunities will allow carbon management or management of the GHG emissions of the product and its supply chain.

### Part 1 Product modelling

A process tree of a product is developed by identifying major processes in the use of raw materials and manufacturing processes of the finished product. The process tree is based on the bill of material (BOM) data and scenarios of the distribution, use and end-of-life stages. Using the process tree, the product system boundary is defined. For data collection, data requirements of the product system, or what data should be collected is defined. Since the product system is vast and includes non trivial processes, it is a normal practice to exclude minor or trivial materials, parts and processes from the system boundary. In this case, fractional contribution of GHG emissions from the parts, materials, and processes to the total GHG emissions of the product can be the cut-off criterion. In addition, it is a normal practice to exclude the following: transport of workers to the factory, transport of consumers to the shop, lighting and heating of factories and offices, and manufacturing and maintenance of capital goods.

For the data collection, the mass flow of all major input and output streams into and from each unit process should be identified and its amount must be quantified. Of particular importance is the data on energy consumption and direct emissions in each process in the process tree. The type of energy that is being consumed or GHG that is being emitted are classified into three categories.

Data requirements if energy source is electricity:

Process level electricity consumption in kWh/kg of main output produced

The emission factor of the electricity is in kg CO<sub>2</sub>/kWh

Data requirements if energy source is fuel:

Type of fuels being used (e.g. natural gas, diesel)

Kilogram or liter of fuel consumed and its energy content/kg of main output produced

The emission factor of the fuel is in kg CO<sub>2</sub>/kg or liter of fuel

Data requirements if direct gas emissions are being produced:

Type of emissions (e.g. CO, CH<sub>4</sub>, N<sub>2</sub>O, SF<sub>6</sub>, HFCs, perfluoro carbons)

kg of gas emitted/kg of main output produced

The GWP of the gas is the equivalency factor

Data collection of the GHG emissions from each life cycle stage in the product system boundary of a product follows the method described below:

**Use of raw materials stage:** This stage consists of the acquisition and processing of natural resources, including raw and ancillary materials, and the associated transport of the resources and materials. It is impractical or impossible to collect the GHG emissions directly from this stage; rather, it is normal practice to use the GHG database of materials, processes, transport, and activities. The GHG database is similar to the GHG emission factor, which is the amount of GHG in CO<sub>2</sub>-eq/kg of materials or per a certain activity such as incineration of a material.

**Manufacturing stage:** This stage consists of the manufacturing of parts and the finished product. In both cases, the GHG emissions from the identified emission sources are measured directly or calculated indirectly. The emission sources can be classified into stationary combustion, mobile combustion, process emissions, fugitive emissions, and indirect emission due to electricity consumption [7]. Identification of emission sources involves the identification of the facilities and activities emitting GHG which are included in the product system boundary. Activity data should be collected at the actual point of discharge of the GHG emission. Examples of the activity data include fuel consumption (e.g. Liquefied natural gas and Bunker-C oil) for boiler and electricity consumption for motors and mechanical equipments, etc.

Since the manufacturing stage data is from the site, the GHG emission data is the site specific data. This needs to be allocated to the functional unit of the product. Thus, allocation of the site specific data is made to generate product specific data. Conventional allocation rule [27] can be applied for this purpose.

**Distribution stage:** GHG emissions mainly stem from the fuel combustion of mobile sources. A distribution scenario based on the product weight, mode of transport, transport distance, and number of products transported in one transfer should be made for the calculation of the GHG emissions.

**Use stage:** A use scenario of the product by the consumer is initially made, including the time of operation in use and the lifetime of the product. The average energy consumption should be estimated by taking into account the product lifetime and consumed electricity (on, off, and standby mode). Since there is no standard for the estimation of the average energy consumption, the scenario used by the Implementing measure of the standby electricity of the Ecodesign directive [13] is recommended.

End-of-life stage: The recycling methods of the recyclable materials and parts and the disposal methods for the remaining waste depend on the actual collection rate and the type and weight of the materials of each part in a product. As such, the end-of-life scenario based on the collection rate, type of materials, and weight of each part in the product should be made for the calculation of the GHG emissions.

### Calculation of GHG emissions of the product system

The data collected from each of the product system boundaries above need to be converted into the GHG emissions data. The calculation is simple. You need to multiply the data (e.g. fuel consumption, electricity consumption, the amount of gas emitted, distance transported, disposal method, etc.) by the corresponding GHG emission factors. A complete example is shown in [Section 5.3](#) for a complex set top box.

Emission factors should be collected from the site investigation, if possible. When emission factors from the site investigation are not available, then national emission factors should be used. When national emission factors are not available, then emission factors given by IPCC can be used.

In many cases, the GHG emission factors of materials, processes, transport, and activities are not available from the IPCC Guideline. Thus there is a need to calculate the GHG emission factors by converting the LCI database of materials, processes, transport, and activities into the corresponding ones. Here, characterization of the LCI database into the global warming impact category using the GWP 100 years can generate the GHG emission factors. For instance, converting the LCI database of polypropylene, cardboard, compounding extrusion, 11.5 t truck transport at 60 km/h speed, Korean electricity, and plastics recycling into the GHG emission factors via characterization gives 1.37 kg CO<sub>2</sub>-eq, 32.6 kg CO<sub>2</sub>-eq/kg, 0.24 kg CO<sub>2</sub>-eq/kg, 29.1 kg CO<sub>2</sub>-eq/t-km, 0.42 kg CO<sub>2</sub>-eq/kWh, and -0.96 kg CO<sub>2</sub>-eq/kg, respectively [14].

For the calculation, it is better to divide the calculation into two separate steps: one is at the process level and the other at the product level.

For each process:

1. Arrange collected data in three categories: fuel, electricity, and direct gas emissions, either in kg liter of fuel, kWh electricity, or kg of gas/kg main output produced.
2. Convert the data by multiplying relevant emission factors for the energy sources used, or the GWP emission factors so that the data can be converted into CO<sub>2</sub> equivalent GHG emissions/kg main output produced.
3. After allocation, the GHG emissions per main output from the unit process to be used for the finished product can be obtained through mass balance. (If no allocation is necessary, the result from step 2 is used in the next step).



For the product system:

Add the GHG emissions data from all individual unit processes to obtain overall GHG emissions of the product system. Note that the contribution by individual unit processes to the finished product should be accounted for in this summation (e.g. this is the same as the Life Cycle Inventory (LCI) calculation procedure).

The GHG emission of a product can be calculated by adding all the GHG emissions from all life cycle stages as shown in equation below.

$$GE = GE_{\text{Raw}} + GE_{\text{Mfg}} + GE_{\text{Dist}} + GE_{\text{Use}} + GE_{\text{Eol}},$$

where

GE: GHG emission of the product (kg CO<sub>2</sub>-eq)

GE<sub>Raw</sub>: GHG emissions from the use of raw materials stage (kg CO<sub>2</sub>-eq)

GE<sub>Mfg</sub>: GHG emissions from the manufacturing stage (kg CO<sub>2</sub>-eq)

GE<sub>Dist</sub>: GHG emission from the GHG emissions of the distribution stage (kg CO<sub>2</sub>-eq)

GE<sub>Use</sub>: GHG emission from the GHG emissions of the use stage (kg CO<sub>2</sub>-eq)

GE<sub>Eol</sub>: GHG emission from the end of life stage (kg CO<sub>2</sub>-eq)

### Alert

#### Product carbon footprint (PCF)

International standardization of the PCF is underway in ISO/TC 207. The standard consists of two parts: quantification of the carbon footprint of a product and communication of the carbon footprint to the market. The fundamental principles and methods of LCA in ISO 14040 series and the type III environmental declaration in ISO 14025 have been adopted for the quantification part and the communication of the PCF standard, respectively. This implies that SMEs may find it difficult to comply with the PCF standard. The requirements on data collection and setting product category rules for communication may be too burdensome and expensive. Industry may need to find a less demanding route for the declaration of PCF once the standard becomes available in the market.

### 2.3.2 Resource Use Efficiency Aspects

The analysis of resource use efficiency considers the possibility, as well as the ease of recycling of a product when its useful life (i.e. value lifetime) ends. In this analysis, the recyclability of the product is often evaluated. To analyze the ease of recycling, several factors, such as the use of composite materials, number of plastics used, coating and painting of the external plastics, are evaluated.

In general, recycling and reuse are considered important design factors for products such as photocopiers. Recycling and reuse considerations incorporate ease of recycling and reuse of parts in the product's structural design. This practice is rather common for those products commonly leased. Although the reused parts from any leasing business have to have the same quality as new products manufacturers of energy-related products intended for sale only have to prove to the public that a detailed quality analysis had been applied to the reused parts (cf. Section 2.4).

Design for easy recycling can be achieved in two consecutive steps. First, calculate the recyclable rate of the product and then set up the recycling rate target of the product being developed. Second, develop solutions to achieve established targets.

In the first step, the recyclability rate can be calculated by analyzing own and competing products in terms of material identification of the parts and measuring their weight based on the recyclability calculation formula:

$$\% \text{ Recyclability} = (\text{total weight of all recyclable parts} / \text{product weight}) \times 100$$

Establish the recyclability target based on the regulatory information on recycling from various countries including the EU's WEEE regulations and the calculated recyclability rate of your own product. In the event that competitors' products have better performance and features with respect to material selection, disassembly, product structural design, and ease of recycling, those aspects should be reflected in the redesign of the product.

In the second step, the following principles can be applied when determining solutions for product development, including packaging, which facilitate recycling:

- Minimize the number of plastics used. Mono-type materials are the best.
- Avoid painting and surface treatment of the external plastics.
- Avoid structural design that makes disassembly difficult when different materials are used, such as metal inserts in the plastic parts.
- Identify material types when using plastic parts.
- Select recyclable materials.
- Implement structural designs that enable easy and quick disassembly of the parts requiring frequent service, the parts with higher recycling value, and those containing hazardous substances.
- Minimize the number of joints such as bolts and nuts, and ensure that disassembly can be done through the use of regular and readily available tools.

Once solutions are developed, resource use efficiency can be evaluated using a matrix similar to the one shown in Table 2.4.

For each evaluation criteria, there are corresponding evaluation scores ranging between 0 and 3. In addition, a weight (representing relative importance or priority) is assigned to each evaluation sub category. The weighted evaluation score of each sub category can be obtained by multiplying the evaluation score by the weight. Based on the weighted evaluation score, the resource use efficiency of the product

**Table 2.4** Evaluation of product resource use efficiency

Category	Sub category	Evaluation criteria	Target	Evaluation results
Product weight	Product weight	Measured weight of product, accessories, and batteries	Weight of product	Product weight,
Recyclability	Recyclability	% Recyclability = (total weight of all recyclable parts/product weight)×100	Large product: 75%, IT product: 65% Small product: 50% (cf. also WEEE targets: <sup>a)</sup> )	Battery weight % Recyclability
Easiness of recycling	Coating and painting of external plastics	% coating/painting not applied = (1–number of parts with coating and painting/number of external plastic parts) × 100	Yes or No per product	Number of parts with coating and painting
	Use of composite materials	Check the presence of composite materials used in the plastic parts exceeding 20 g weight	Yes or No per product	Parts names concerned and type of composite materials
	Number of plastics used	Plastics in the external cover and housing	Number of plastic types	Number and type
	Material name of the plastic parts identified	% identification = (number of parts identified/total number of parts considered) × 100	100% material identification	Number of parts considered Number of parts with material ID

<sup>a</sup>Numbers in this table are for illustrative purposes only

being developed can be calculated. If the weighted score does not meet the target, iteration may be necessary to choose an alternative design.

### ***2.3.3 Degree of Environmental Hazard Aspects***

The analysis of the degree of environmental hazard considers critical substances and toxicity of materials and parts used in the product (including packaging). The analysis includes screening of parts from suppliers with respect to the presence of hazardous substances regulated by law and the company's own requirements. Controlled hazardous substances contained in the supplied parts and product include:

- Class I controlled materials (all six RoHS regulated substances)
- Class II controlled materials
- Company specific controlled materials
- Halogen containing materials
- Volatile organic compounds (VOC) emissions during the use of the product

The analysis can lead to the substitution of materials and/or parts going into the product.

When analyzing the degree of environmental hazard of a product, and developing solutions to meet the requirements of the regulations, the relevant hazardous material related requirements can be identified by reviewing the regulations of various countries, and other requirements related to ecolabelling programs, environmental non-governmental organizations (NGOs), and competitor trends. This should include the identification of requirements to be reflected in the product design, and whether or not to pursue ecolabel certification. In particular, the following should be considered:

- Meet the legal requirements from the EU, China, Japan, Korea, and other countries on the RoHS-like regulations.
- Meet the ecolabelling requirements of a specific product group with respect to hazardous substances.
- Prepare for expected regulations on substances such as polyvinyl chloride (PVC), antimony, beryllium, and brominated flame retardants (BFRs) by listing them as non-use, hazardous, or controlled substances.
- Select bioplastics and materials that reduce GHG emissions as part of a competitive differentiation strategy.

Of particular significance is the implementation of a parts control system to ensure the absence of newly established non-use substances in components and parts. A control system should typically require approval of the parts after (a) independent verification (perhaps requiring laboratory analysis) and include (b) control

of the parts' manufacturing system to ensure the same parts are made as those passing any verification or the laboratory test.

New materials, using no PVCs or antimony, should be developed in co-operation with material suppliers. The entire control process can be implemented by adding the newly enlisted non-use substances into the existing parts control process such as the Green Partner or Eco-Partner program. Don't forget to avoid the "old" very toxic and, in many countries, already prohibited materials like asbestos, PCB, etc. also in those countries where the application is still allowed! These substances are usually no longer used in consumer products but in plants and in projects.

Although the control limit of hazardous substances may be met at the parts level, the product level should also be verified to ensure an absence of hazardous substances. Factors such as heat dissipation from the product during the use stage may trigger the emission of VOCs, which could thereby exceed the regulated level.

The degree of environmental hazard of the product can be evaluated using a matrix similar to the one shown in Table 2.5 which gives an example of the evaluation of the environmental hazardousness of the product including the controlled substances, halogen free parts, and VOC emissions.

The same evaluation logic as that described under Table 2.4 can be applied. Based on the weighted score, the degree of environmental hazard of the product being developed is evaluated. If the weighted score does not meet the target, iteration may be necessary to choose alternative design options like, for example, the selection of alternative parts.

### ***2.3.4 Extended Material Aspects***

The analysis of the extended use of materials should include consideration of the use of recycled materials or reused parts and components and the use of renewable materials in a product. For the assessment of the use of recycled materials, use of recyclable materials and reusable parts of the waste product are considered. In the case of the use of renewable materials, selection of plant derived materials can be considered.

The extended material aspects of a product are normally assessed using an approach described in Table 2.6.

The same evaluation logic applies here as that described under Table 2.4. Based on the weighted score, the extended material aspects of the product being developed can be evaluated. If the weighted score does not meet the target, iteration may be necessary to choose an alternative design option, such as the selection of alternative materials and parts.

**Table 2.5** Evaluation of the environmental hazardousness of the product

Category	Sub-category	Evaluation criteria	Target	Evaluation results
Class I controlled substances	Six substances under the RoHS regulations	Check the use of the six regulated substances in the product, packaging, and batteries	Within the control limit of the six RoHS-regulated substances	Meet the regulated (target) value? For product: avoid all six substances Packaging and battery: four heavy metals
Class II controlled substances	Specific substances controlled by the company	Check the use of class II controlled substances in the product, packaging, and batteries	Within control limit of the company-regulated substances	Meet the company-regulated (target) value?
Halogen-free	Power and other cords	Check the use of halogen-free materials and no PVC use	Variable per each product group	Power cords with no PVC use halogen-free (power) cords
	Structural parts	Check the use of halogen, free materials especially no PVC/Tetra-bromo-bisphenol A (TBBPA) use	Yes, if no TBBPA use Variable per each product group	No PVC use No TBBPA use All halogen-free
	Printed Wiring Boards	Check the use of halogen-free materials and especially no TBBPA use	Yes, if no TBBPA use Variable per each product group	No TBBPA use All halogen-free
	Packaging	Check the use of halogen-free materials	Yes, if no PVC use	No PVC use All halogen-free
VOC	VOC	Check the compliance with the VOC emission requirements in the ecolabelling and European Computer Manufacturing Association (ECMA)-328 criteria	Variable per each product group	Measure VOC level (dust, ozone, benzene, total VOC, toluene, etc.)

**Table 2.6** Extended material aspects of products

Category	Sub category	Evaluation criteria	Target	Evaluation results
Use of recycled materials	Use of recycled materials	Amount of recycled materials present in a product	Variable per each product group	Yes/No of the use of recycled materials Part name, type of recycled material, percentage recycled content in the product
	Use of reusable parts	Amount of reused parts and components in a product	Variable per each product group	Yes/No of the use of reused parts Part name; percentage reused parts and component content in the product
Use of eco-friendly materials	Use of plant derived materials	Used for products, packaging, and accessories, except paper packaging	Variable per each product group	Yes/No of the use of plant-derived material Part name, type of material, percentage plant-derived material in the part
	Use of more eco-friendly materials (excluding plant derived materials)	Used for products, packaging and accessories, except plant derived plastics	Variable per each product group	Yes/No of the use of eco-friendly material Part name, type of material, percentage eco innovation material in the part (these are parameters for the evaluation of the eco innovation aspects or extended material aspects: same as above )

Checklist for product analysis

Assessment questions	Answer	Comments	Recommended follow-up activities	Related sections
Have you analyzed the environmental aspects of the product from the perspective of the product's life cycle?	Yes ☺ No ☹	The intent of the product's environmental aspect analysis is to identify the significant life cycle based environmental parameters of the product for improvement through Ecodesign	Perform analysis of the product's environmental aspects using tools such as LCT matrix or LCA	2.5, 3.3

(continued)

Checklist for product analysis (continued)

Assessment questions	Answer	Comments	Recommended follow-up activities	Related sections
Have you analyzed the environmental aspects of the product from the perspective of stakeholder requirements?	Yes ☺	The purpose of the stakeholder requirements analysis is to identify the significant environmental parameters relating to stakeholders in order to improve the product through Ecodesign	Perform analysis of the stakeholder requirements using tools such as EQFD and EBM	3.3
	No ☹			
Do you intend to develop and communicate the product carbon footprint (PCF)?	Yes ☺	The product carbon footprint is an environmental profile of the product	Follow international standards, such as ISO's PCF standard	
	No ☹			
Have you evaluated the resource use efficiency of the product?	Yes ☺	The resource use efficiency analysis considers the possibilities of recycling as well as ease of recycling of a product when its useful life ends	Evaluate the resource use efficiency of the product – calculate recycling rates	2.5, 3.3
	No ☹			
Have you evaluated the degree of environmental hazard of the product?	Yes ☺	Consider critical substances and toxicity of materials and parts used in the product (including packaging)	Evaluate the degree of environmental hazard of the product Comply with RoHS, etc. Define your own list of class II controlled substances	2.4, 2.5
	No ☹			
Have you evaluated the extended material aspects of the product?	Yes ☺	Reuse of parts and components, using recycled or even renewable materials, are aspects of innovation and cost efficiency	Evaluate rate of recycled material, reused part, components and eco-friendly material present in the product	2.5
	No ☹			

## 2.4 Production Analysis

In this section, the analysis of the environmental aspects related to processing materials and substances is described. The view of these materials and components is from the perspective of production, development, and purchasing but also includes



potential risks associated with the suppliers. Reuseability and recycling of components and materials can be investigated through the disassembly and reuse analysis.

The selection of materials is also important for the technologies applied in the production processes and for the planned recycling. An analysis of these processes should be undertaken to identify potential improvements or material substitutions.

### ***2.4.1 Information on Materials and Substances***

In a globalized world, many producers have become assemblers. They purchase most of the component parts within their product's value chain. As a result, the manufacturer, or assembler, will most often have little or no information about the environmental aspects or composition of the components.

In order to conduct a competent inventory analysis of its own production to determine environmental impact, the company needs to know which materials are supplied directly or in components. In addition, customers, governments, NGOs, or regulatory agencies may require information about the use or application of prohibited hazardous substances. Also, some of this data is relevant in order to ensure workplace safety. Threshold limits in the component or complete product must be calculated for some substances, and this is only possible if the other quantities in the component are known.

There is also some potential risk of price increases resulting from material scarcity or market speculation. Some prices have increased many times over and, for some substances like indium, significant price increases should not be surprising. Substances such as indium should be evaluated to determine price risks. For those materials with high price risk: (a) substitute materials should be sought, (b) quantities consumed significantly reduced, or (c) a recycling process developed. For other material such as noble metals, the environmental impact through mining is extremely high.

During the analysis, it should be determined whether a complete production information system is available. Such a system should facilitate finding answers to questions about the material record of all chemicals or materials used, especially hazardous substances. Rare and risky substances should, therefore, be easily identified. All volumes of materials used in the production of the products should be available. The procurement system should require the supply of the relevant information. A system should guarantee the correct supply of materials and components with the desired environmental properties. Regular reporting from suppliers must be ensured.

#### **2.4.1.1 Special Information About Materials and Substances**

Legal requirements, e.g. from REACH [15] demand that information about substances in down-stream use be available, i.e. in applications. As about 30,000 substances are currently under discussion, it will not make sense to restrict the

information of the contents of a product. Therefore, the total content of substances should be known to a significant degree.

Lists of substances to be avoided can be provided by associations like the DigitalEurope (voice of European digital economy including IT, communication and consumer products) [16] or the German Electrical and Electronic Manufacturers' Association (ZVEI) [17]. These lists contain those substances under discussion that will probably be restricted in the next few years. These lists can also be used in risk analysis, and to identify where alternative materials are likely to be needed.

Recycling information about hazardous substances in waste products is not currently widely required by recyclers. Most recyclers have experience with the usual E&E (electrical and electronic) products. Nevertheless, it might be beneficial to know which substances have residual value.

In this complicated area, standardization is necessary (e.g. IEC PAS 61906) and already under development (e.g. IEC 62474). Substance information is offered on three levels:

Product – e.g. for recycling costs

Component – e.g. for reuse

Material – e.g. for evaluation of required threshold limits, cost development calculation.

These standards also define the data format, thereby allowing software companies to offer programs for many users. It will not make sense for every company to develop its own program, as data will have to be freely exchanged.

To reduce the amount of data by factors of ten to one hundred, different associations and companies have developed standardized average material records for component families [18]. In addition, the concept can also be extended to complete standard components and products which are often very similar. Equally, information is available for plastics, buildings, and/or cars [19]. Information about substances is also a necessary input for LCA. Data sets are already available for buildings, cars, and plastics from the various organizations. In the near future, it can be expected that suppliers will be required to provide this kind of data with every order. Additionally, standardized procedures for material declaration will be required and will, most likely, soon be available.

Materials information or component information must fit the production information system. From there, an input/output analysis is undertaken. The material record of the complete product will also require this information. Environmental data for production and for components or products are different. Many materials used in production will never end up in the product. Naturally, toxic effects can vary from person to person and, thus, legal requirements can also differ. In addition, information to the public may have different requirements. Thus environmental improvement of the product and of production should be planned individually.

The management of materials in products and components, whether hazardous or not, should be part of the management system [cf. Section 2.5]. Environmental

information about standard plants and especially energy consumption, is often not directly available from producers. With motors or pump controls, control of ovens, fans, power supplies, etc., energy consumption can be reduced by about 50% compared with the standard configuration [20].

In some regions, asbestos and other very toxic materials are still allowed. Regardless, information on all toxic materials is needed because legal requirements in one country are not lessened because of less restrictive regulations in other countries. Insurance companies may well choose to deny insurance coverage if it were discovered that such toxic materials were used! And if illnesses were to occur, there could be successful lawsuits.

Purchasing departments can, as a first step, use the above mentioned lists from industry associations for substances already prohibited in many countries, and develop additional lists of substances to be avoided for their own business.

When examining energy consumption of a production line, the most energy consuming components are usually drives, pumps, ovens, and exhaust systems. Often, only one of these consumes the largest percentage of the total energy. With improvement of this main component alone, in some cases, up to half of the energy consumption of the complete production line can be saved. It is often enough to build in a control element to reduce energy consumption. However, in most cases a new main component, such as a more controlled soldering oven, would be needed. Planning for this kind of component change may be lengthy, depending on whether the oven supplier (in this example) actually has such an energy saving component available. Nonetheless, the identification of the energy saving opportunity may well stimulate the oven manufacturer to develop the more energy efficient component.

Management usually has to authorize this kind of equipment replacement because of the level of investment involved. Many projects are rejected on the argument that the payback period on the investment is too long, although, payback times can be rather short if the frame of reference is the entire life cycle of the product or the whole production process.

The afore-mentioned subjects should be integrated into the order's management process and should be part of the overall energy management of a factory or plant. To receive environmentally improved components from suppliers on a timely basis, the following steps are suggested:

1. Plan ahead for energy saving investments.
2. Calculate payback times within the life cycle of the product or the whole production process, and include energy price trends.
3. Involve potential suppliers early in the process and certainly before any orders are placed.

Check which additional special data your company requires for the business. Define special materials with risks in product or production. Also identify components in the production line with high energy consumption.

**Alert**

Product vs. production information:

Be careful not to confuse product information with production information. Materials used in a production process often do not remain in the product. The legal requirements for substances in products are normally different from those used during production. Also, the internal and external target groups that might be interested in the information will be different.

**Alert**

Data becomes outdated:

Data supplied from authorized institutions or industry associations can often be old or out of date. Especially LCA data might therefore not be comparable.

**2.4.1.2 Disassembly Analysis of Components**

For car manufacturers, disassembly information is part of the first conformity assessment. Using the standardized “Recycling evaluation method” (REM) [21], a theoretical value for recyclability can be calculated. For the E&E industry, with its many product variations and modifications, this method is not applicable. But every manager should be aware of the degree of ease with which his product can be disassembled. Such information can provide valuable clues for assembly, and reduces assembly costs. Also, those companies who choose to reuse components already have to plan for easy disassembly. Software programs are available with standard disassembly times [22].

Alternatively, a recycler can measure the disassembly time of a product and provide important feedback for those joints that are difficult to separate. Difficult disassembly is a synonym for higher costs! Thus, the design and the hierarchical structure of the product and components should be modified in cooperation with the suppliers.

In summary, disassembly analysis can help to significantly reduce assembly costs! This analysis, together with planning for reuse of components and designing for minimum joints and junctions, facilitates the reuse of components. If components should not be reused, the analysis can be different. For the recovery of pure mono-type plastics, disassembly is not the only way. It can also be done by special shredding technologies followed by automated sorting.

**2.4.1.3 Reuse Analysis of Components**

Reuse analysis is more than disassembly analysis and can, for SMEs, usually only happen in cooperation with suppliers. Reuse is an objective of product planning together with ease of disassembly (e.g. by avoiding joints that cannot easily be

taken apart). Reuse analysis also includes the calculation of costs for requalification of the components.

Reuse of components and products offers the highest value-added, especially for capital goods. Components from these products or plants are often like new (i.e. undamaged), and in fact frequently cannot be distinguished from the new ones. The lifetime of the product or component can be long, often up to 30–50 years. Customers are known and components can be taken back if the customer plans to buy a new product.

Reuse analysis can be also done for service applications and as input to new product development. The highest value-added is when new products are manufactured with components that are “qualified-as-good-as-new” (e.g. defined in IEC 62309).

Standards are in place that define the conditions for requalification from the take-back process and include the documentation and customer information requirements [23].

The reuse analysis consists of:

- A determination of valuable components
- The selection of the qualification procedures for the components (testability)
- A calculation of costs and benefits for the refurbishment process
- An investigation into the possibility of planning for several product generations
- A check of the acceptability of the requalified components by customers

### **Example**

The analysis of the mounting plate of a computer showed that all plates were different by some mm. The cost of a new plate was in the range of 20 €. As no stress occurs on the part, visual testing is enough to investigate the state of this component. After some cleaning, it can normally be reused as is. Only this simple part constitutes 3–4% of the total costs. Therefore, if this part is qualified as-good-as new and reused, the product could become cheaper by about the same percentage.

For a cost/benefit analysis of a component, the costs and benefits should be compared, as shown in Table 2.7.

Typical costs for testing, disassembly, and cleaning can be in the range of 1–2 €. The value added for some parts can also be very high especially for components “qualified-as-good-as-new” according to IEC 62309. It should be mentioned that a modern quality management system should be installed together with a complete and documented procedure for quality testing. No additional risk should be transferred to a customer and customers must be fully informed about the reuse. As a benefit to the customers, the manufacturers, and the environment, the new products with re-qualified components can be much cheaper and of better quality than new ones.

**Table 2.7** Benefits and costs for the refurbishment and reuse of components

Benefit	Cost
– Avoided cost for a new component (price decrease of component over time has to be considered)	– Quality testing (e.g. acc. to IEC 62309)
– Sales of some parts are also possible as spare parts, for service and possibility of other applications	– Disassembly
– Recycling benefit for valuable material	– Cleaning
	– Software testing and upgrade
	– Recycling/deposition cost
	– Documentation and information

A useful strategy is to evaluate all components “of interest” when designing a new product. Those products that have components that are planned for reuse should be designed in such a way as to ensure easy removal. In addition, the application of such components should be planned for several product generations, because the first totally new products will only be returned after some years and the maximum take-back might only occur when the next generation of the product is placed on the market. The full potential of the used components could, therefore, only be realized when the next product generations are produced. The percentage of reusable components can typically be between 15–25% of a complete product. Some components can have several lives.

For public tenders for large projects such as train stations, metro systems, or power plants, questions about the lifetime of components can arise and can become a determining factor for the customer’s cost planning. Examples can be found in the cases of Xerox or Siemens Healthcare [24].

### Alert

The highest benefit from the re-qualified components can be achieved if the product is produced as a serial product and the components can be integrated into the production line of a new product. But

- Requalification can also be done by suppliers who have the required test equipment
- SMEs can organize take back of their used equipment, perhaps together with a competitor to achieve economically viable volumes
- Electronic components are often difficult to test and can therefore often not be reused in new products
- The highest value-added is often located in simple and usually inexpensive parts
- Reuse is also possible for components from the waste stream of short-life products
- Additional advantages are found with low age products because components may be like new
- Leasing is not the only way to get products back for reuse. In many cases, a good customer relationship can be built which enables reuse

After it has been decided how to manage the reuse of components, an investigation of the recycler market will show variation in qualifications and expertise. Some can only shred, others can disassemble and supply valuable components, some can provide storage, some have a license for special waste treatment, and for others it is possible to resell plastics with quality as new.

#### 2.4.1.4 Organising Recycling

The knowledge about the way a recycler operates and knowledge about his technical equipment is essential to select appropriate and useable recyclable materials. Some recyclers only operate shredders; others disassemble components and housings and sort plastics. A few can also granulate plastics with “as new” quality. Many companies also forget that the recycler is also a supplier. For some, the recycler seems only to exist as a black box. Therefore development engineers, who follow a lot of guidelines for Ecodesign, become quite astonished to find that not all recyclers can recycle material that has been selected as most environmentally compatible! To optimize recycling of their own products, an analysis of the recyclers and their recycling technologies is unavoidable. If no reuse of components is planned, and no materials are to be reused, the recycler with a simple shredder might be the best choice. But if a company plans to utilize expensive technical plastics, such as polycarbonates, and wants to reuse them, then either (a) a chain of several recyclers that collectively can disassemble, sort, collect to achieve amounts sufficient for regranulation, or (b) a special plastic recycler will be required.

So the first question should be: How is the product collected for recycling? Are there legal requirements? In Europe the WEEE enables collection and/or individual take back. It also requires the take back and recycling of some capital goods like medical equipment. Usually, recyclers are very experienced with the standard E&E products and usually know how to dismantle them.

One group of recyclers may prefer a detailed disassembly because they can earn more money with clean fractions. Another group may recycle by using shredder technology. Both approaches enable separation of special materials as required by European law. A company in the recycling business can compare component or commodity prices with the cost of operating the different options for recycling. Some recyclers already offer the disassembly of spare parts and the storage of these parts for service purposes. Combinations of technologies can include thermal treatments with heat recovery or chemical conversions. They use or mix plastic fractions. Some need a high temperature furnace to, for example, crack the brominated flame retardants [Annex II of WEEE].

The ranking of reuse of products and components after take-back has become a higher priority for the European waste legislation. So it will be worthwhile for every company to think about reuse and recovery together and not concentrate only on recovery. In addition, recovery rates will have to integrate the quantity of reused components and products. As it is planned to increase the required recovery ratio, reuse becomes additionally important because its ratio can be included.

If a recycler requires information about any disturbing impurities, a special checklist can be used, such as the one developed by the European Association for Household Appliances (CECED, French: Conseil Européen de la construction d'appareils Domestiques) or the European Recycler Association (ERA). On the other hand, a company can decide which materials should be separated, and can offer these materials if they are easy to dismantle (e.g. plastic housings). Generally, the total cost will decide what is selected. In some cases, a company's own system can be of interest, such as the system for printer cartridges or special recycling of CDs for expensive polycarbonates. Such decisions can usually only be taken by big companies alone or can become a collective solution. However, generally the collected quantities are too small for special treatment. Internationally, a take-back standard is being discussed by countries where no legal requirements currently exist.

The quality check conducted by the recycler should cover compliance with the legal requirements to ensure a high standard of recycling. In many countries, recyclers have to be licensed by the government, and their recycling processes have to be certified by auditors. If the quality of the recycler does not meet the requirements of your company, any co-operation with the recycler should end.

It must be mentioned that the responsibility for recycling of a company's own products in Europe is a regulatory requirement for manufacturers.

The related investigation should include questions such as:

- How is my product recycled? What technologies are used?
- How can my company profit (for example, with the selection and recycling of special materials or cost reduction with the avoidance of some materials)?
- How can we participate in a system or should we do it individually? Together with competitors?
- Does a company make a profit or is recycling a cost factor? If it is expensive, how can it become cheaper or profitable?
- How can a company avoid or reduce recycling costs? Actions should be taken together with industry associations, competitors, government or individually.
- Which approach fits best to all markets of the product worldwide?
- How reliable are the recyclers (legal requirements)? Is there a risk for the company?

This recycling and recovery analysis will help you find the best technology for your product. In conclusion, environmentally poor production processes should be changed.

## ***2.4.2 Production Process Analysis***

According to Graedel & Allenby [25], three classes of processes/systems can be distinguished:



- Type III is cyclic and sustainable
- Type II could be approached today by developing feedback and cycling loops (especially for scarce materials)
- Type I loses resources.

Everybody can evaluate in which class his process is located: Today most will certainly be the type I process.

The simple matrix concept from Graedel & Allenby yields a more complete picture of a production process. It helps to evaluate the sustainability of the process and goes beyond LCA. The following items could be evaluated for the different life cycle stages

- Process compatibility
- Materials compatibility
- Component compatibility
- Performance
- Energy consumption
- Availability
- Cost
- Competitive implications
- Application system (use by different customers for different purpose)
- Others

Evaluation can occur in four steps, from “no concern”, “minor concern”, “moderate concern” to “significant concern”, corresponding to the numbers 1–4, respectively. A group of experts from a company can do the process evaluation themselves, and should develop if necessary its own checklists. An evaluation of different process options afterwards could happen using the following criteria:

- Toxicity/exposure
- Environmental effects and impact, also by life cycle inventory
- Production criteria (investment, easiness, etc.)
- Social, political, and legal trends
- Cost and technical trends

The same ranking method could be used as for the process audit above. The most important point must be to get a decision to change the process in those areas where there is significant concern. Perhaps a more precise analysis will be necessary.

Nevertheless, a trend analysis has to follow these evaluations. If the technology already poses hazards to the environment, to health, or creates any kind of potential risk, then it should be changed or a new technology be developed if an alternative is not available.

It is an important lesson – substances that are going to be prohibited in one country will probably be also prohibited in other countries. Substances with high environmental impact, or rare (or scarce) substances will be restricted sooner or later, or become too expensive. Therefore, when information about

any forthcoming legislation is released, one can expect similar regulatory action in other countries. Even if processes that use already targeted toxic substances are run in a closed loop, the time for the process may well soon run out.

Many alternative processes may exist for the same task. Soldering to form fixed joints can in many cases be replaced by compression technology without using chemicals. Preventive health check costs for employees dealing with very toxic lead can be saved, no lead emissions occur and many more problems combined with the application of lead can be avoided. Other solder technologies are also available or adhesives can be applied. An environmental evaluation and a cost comparison of the different technologies will probably show interesting opportunities.

**Alert**

Managers may choose to switch from a toxic substance to a new substance estimated to be non-toxic. Unfortunately, there may be little known about the new substances, and thus risks are created. When substances such as chloro carbons, chlorofluoro carbons (CFC), and some flame retardants were introduced, the environmental or toxic effects were only known years later, and then substitutes were actively sought out. This is inefficient. In the future, more information will be required by legislation (e.g. in REACH regulation). In many cases, chemicals may not be necessary at all.

Checklist for production analysis

Assessment questions	Answer	Comments	Recommended follow-up activities	Related sections
Is there a systematic procedure installed to gather all required information about chemicals, materials?	Yes ☺	Integrate the software systems of the suppliers, use checklists, define responsibilities, also gather quality and environmental information	Optimize system	2.3, 3.3, 3.4, 4.3, 4.4, 4.5
	No ☹			
Is it certain that all components or materials are supplied with the correct environmental properties?	Yes ☺	Random checks necessary	Optimize system	2.3, 3.3, 3.4
	No ☹			
Is it checked by a disassembly analysis which components form a barrier for reuse?	Yes ☺	Simple connections required, otherwise reuse too expensive	Analyze all relevant components	2.3, 3.3
	No ☹			

(continued)

Checklist for product analysis (continued)

Assessment questions	Answer	Comments	Recommended follow-up activities	Related sections
Is assembly improved by disassembly investigations?	Yes ☺	Easy disassembly often means easy assembly! High cost reduction in production possible	Apply software	2.3, 3.3, 3.4
	No ☹			
Is reuse evaluated and is a systematic approach for reuse of components and products in place?	Yes ☺	Long-term planning required, high cost reduction possible	Install quality system according to IEC 62309	2.3, 3.3, 3.4
	No ☹			
Does market intelligence identify which material can easily be recycled?	Yes ☺	Targets: Clean fractions, monotype plastics (material recycling is easier with capital goods as producer gets back his own product)	Analyse markets e.g. with plastics Install own system	2.3, 3.3, 3.4
	No ☹			
Do recyclers confirm which recovery procedures are best for the product and environment?	Yes ☺	Possibility and reality is often different with recyclers	Observe market situation	2.3, 3.3, 3.4
	No ☹			
Is there a production process evaluation in place considering environmental impact?	Yes ☺	Changes have to be planned in time. Otherwise jobs are at stake, competitors could be quicker	Continuous evaluation	3.4, 4.4
	No ☹			
Are trends determined for production processes and measures for change?	Yes ☺	Observe forthcoming legislation	Ongoing	2.5, 3.4, 4.4
	No ☹			

## 2.5 Management Analysis

### 2.5.1 Current Situation

In general, an organization should check which management systems are already available (cf. Section 2.1). Often there are quality management, environmental management, and health and safety management systems available. Many companies have opted for an integrated management system that combines all of them.

Ecodesign, as a process, can be integrated in ISO 14001 as well as in ISO 9001. Related requirements are listed in Annexes IV and V of the Ecodesign directive. It should be analyzed in detail to determine which environmental processes are already installed besides the normal processes in industrial environmental protection (cf. Section 2.1). The following processes are usually either not in place or are incompletely installed in companies and therefore some systematic approaches are missing:

- *Chemicals and materials*: Purchasing, development, treatment and storage, production, hazardous substances, phase out of hazardous substances, release of hazardous substances, availability of required data. Reuse and resale of materials. Is production software available that deals with the flow of materials? Are required data directly provided by the suppliers?
- *Energy*: Analysis of consumption, methodology of measurement, and measures for reduction.
- *Take back, recycling and recovery*: Collection organized (difference between consumer and capital goods), recyclers evaluated and selected, customers informed.
- *Reuse*: Components for reuse analyzed, check for reuse (also as new) in own production, refurbishment of whole products, resale of components and products, application of reusable components as spare parts.
- *Trends*: Legal trends, new standards, competition, comparison with own strategy.
- *Risks*: Cost evaluation, potential time schedule, measure for development and production.
- *Innovation*: Systematic search for alternatives with high reduction potential for materials and processes, evaluation, introduction of innovation process.
- *Production technology evaluation*: Evaluation for sustainability.
- *Communication*: Success to public and customer, crisis communication, preparation of information documents such as environmental product declarations according to ISO 14025.

In all cases, management procedures are required. All management systems nationally installed should also be in place at international locations. Management approaches also require the systematic application of tools. In a kind of toolbox, these tools could be offered by an internal department or by consultants.

Examples include: Design rules, LCA, environmental product declaration, EQFD, emission trading, and PCF. Whereas design procedures are standardized for products as shown in IEC 62430 [26], plants or software recommendations are lacking. In Annexes 1 and 2 there are examples for both.

Reporting structures are another part of a good management system. Aside from legally required industrial environmental reporting, more and more data are required for products and production, including quantities of materials, hazardous substances, quantity of green products in portfolio. Often, the reporting of the environmental costs can improve management awareness. In any case, a report to the board member responsible for environmental issues, which includes improvement targets and measures, should be provided annually. A review of the achievements and outcomes is also necessary.

In Annex 3, a simple scheme for internal environmental cost reporting comparable to quality cost reporting is proposed. Environmental reporting in more detail should be a part of the annual business report or be a part of an additional sustainability report. Minimum requirements for such reports are often set by the government.

### 2.5.2 Responsibilities

When environmental problems occur and the justice system is engaged, responsibility is usually assigned by a court. To avoid such problems in advance, a clear structure of responsibilities from the board down to the environmental processes should be organized. In designating accountability, everyone is informed about his respective responsibilities. In complex company structures, a level concept can be applied, as shown in Table 2.8.

In some cases, all of the related tasks and responsibilities are described in a booklet about the “Basic Principles of Environmental Protection” authorized by the responsible board member. Such a booklet can also be given to interested parties outside the company. Such a guide is beyond the detailed description of the processes and responsibilities in the process handbook in a management system.

Employees participating in associations, government, or standardization committees with environmental tasks, should also receive regular updates about related trends.

**Alert:**

A systematic organization does not require full-time experts. Some managers may have the groundless fear that more employees are needed for such an organization.

Also, the process for designating responsibility does not require much work, but does enable a systematic structure. Wherever responsibilities for Ecodesign are “naturally” with a special manager, frequently the product manager, a letter to him or her with the information about the environmental duties might be sufficient.

**Table 2.8** Responsibility levels in a company with responsible persons and assisting environmental experts

Level	Responsible person	Assisting person
Board	Board member with environmental responsibility	Environmental manager at corporate level
Group/plant	Group/plant manager	Environmental manager of group or plant
Process	Process manager	Environmental process expert
Product	Product manager <sup>a</sup> (often the group manager)	Environmental product expert (might be the same environmental manager as at group level)

<sup>a</sup>The real responsibility for the product is usually on the highest – the group level, or with SME on the board level! Product managers often bear limited responsibility. Plant managers usually have the responsibility for industrial environmental protection

### 2.5.3 Risk Management

Achieving the guarantee of threshold limits of certain hazardous substances is not easy. It is combined with defined analytical procedures and a random check of some samples. This is similar to checking other physical properties and the energy consumption of a product. As it is part of the incoming inspection, it will be the task of the quality department to conduct the checks. Quality management should check the properties of the materials, but also make sure that corresponding requirements are placed in the software for orders. The difference between the identification of normal failures and environmental ones is that, in the case of an environmental “failure”, the company may be in violation of the law. So an early warning system is required that combines experts from quality, environment, and technology. The information from the supplier must be gathered and evaluated. Required properties must be systematically integrated in contracts.

A new task for a quality engineer can be to evaluate risks for the company from environmental failures in purchased goods, components or materials, overly delayed development, or new legislation. A management system concerning environmental risks will include reporting, potential costs, and an action plan. Forthcoming legislation should be investigated, as should international regulatory action, standards under development, and environmental progress of competitors. An example for the risk assessment procedure can be found in Annex 4. In Annex 5, an example for the cost risk calculation combined with forthcoming legislation is given.

The process to make sure that no prohibited substances will be used in a product should require: (i) that suppliers answer questionnaires, (ii) inclusion of the requirements in contracts, (iii) material testing, and (iv) sample preparation if necessary. Also, review steps should be integrated into every product development scheme. Some standards for that purpose are under development or have already been developed by IEC TC 111 [e.g. sample preparation; hazardous substance management; analytical procedures]. Because of complexity, data management must also be installed as part of the management system. A checklist for the requirements of a material management is added in Annex 6.

#### Checklist for Management Analysis

Assessment questions	Answer	Comments	Recommended follow-up activities	Related sections
Do you have environmental management systems in place?	Yes ☺ No ☹	ISO 14001, EMAS	International extension	2.4, 3.5
Is Ecodesign already included in a management system?	Yes ☺ No ☹	IEC 62 430, Ecodesign directive Annex IV/V, in ISO 9001 or ISO 14001, integrated management system	Review	2.3, 3.5

(continued)

Checklist for management analysis (continued)

Assessment questions	Answer	Comments	Recommended follow-up activities	Related sections
In management systems, are missing environmental processes identified and installation planned?	Yes ☺ No ☹	Energy, recycling, communication, chemicals, software	Continuous extension	2.3, 2.4, 3.5
Are missing environmental tools identified and application planned?	Yes ☺ No ☹	LCA, EPD, Design rules, PCF, EQFD,	Extension	2.3, 3.3,
Are environmental responsibilities checked at all levels and are responsible persons nominated?	Yes ☺ No ☹	Responsibility at management level, expert-level assistance required	Assign responsibilities also for new processes	2.3, 2.4, 3.5
Is a document available describing all environmental tasks, responsibilities, and processes?	Yes ☺ No ☹	Environmental principles are also a guide for customers and the public	Annual check of validity	2.3, 2.4, 3.5
Is quality management involved in checking environmental properties of components, materials and products?	Yes ☺ No ☹	Incoming tests required, specifications required, Integration in software systems, contracts required	Update regularly	1.2, 2.3, 2.4, 3.5
Have sources been identified for systematic information about trends in legislation and standards?	Yes ☺ No ☹	Sources could be associations, consultants	Continuous participation	1.2
Has risk management been installed for environmental risks?	Yes ☺ No ☹	Includes trend analysis with legislation, standards, competition	Annual update	1.2, 2.3, 2.4, 3.5
Is an early warning system in place to identify environmental problems with components or materials in time and to inform the management?	Yes ☺ No ☹	Problems can come from suppliers, from public, and from media. Authorized persons must be available to manage a crisis	Test system	1.2, 3.5

## 2.6 Conclusion of Situation Analysis

Results of the afore-mentioned sections might give answers to the following questions: Which product fits the market best? What does the market expect? Which is the environmental part of the product profile? What should be expected from suppliers as additional support? What is missing in the management system?

But before functionalities are selected, a check for plausibility should be undertaken:

- Where are the contradictions?
- What does not fit together (functionalities, properties)?

### **Explanation**

Easy disassembly of valuable components for reuse must be managed if their reuse is being planned. Planning for several product generations will frequently facilitate higher rates of reuse. All the requirements have to be counter-checked one by one.

- Which functionalities are required for the product and what is more or less combined with the application in the corresponding system?

### **Explanation**

A refrigerator does not only supply cooling but also storage with slow fermentation. In Korea, a refrigerator provides storage and slow fermentation for “Kimchi”, which is a fermented vegetable similar to German Sauerkraut. In Korea and Japan, washing laundry in cold water is included in the washing cycle, compared with washing in Europe where water temperature can be as high as up to 90°C.

- What does the system approach really mean for my product? Are there several systems into which my product fits?

### **Explanation**

A System approach means understanding the role of the application. For the example of the *instabus EIB*® (a controller product family for all energy-consuming applications in a house) it means that with some modifications, the product can be applied to many functions like lighting, alarms, kitchen controls,



shades, switching or dimming in the "house" system. Very similar products can be designed and changed in function by software. By using a system approach, products better fit the requirements of the customer and lessen their environmental impact like non-hazardous flame retardants, lower incineration load, less wires from the main panel. If product families are developed, the environmental impact can, in total, be minimized as compared with the isolated development of individual products, each with their own special function. For an old building, installation costs can be high. The product, as a controller, could however, fit other systems such as those in industrial buildings.

- Which scenarios would be valid for the future development of the system and which consequences could occur for my product?

### **Explanation**

With scenario analysis, the future opportunities of a product can be estimated. Which modifications or services might be of interest? In a special case, a question might be: How many homeowners could install this relatively expensive control equipment of an *instabus EIB*<sup>®</sup>? How much energy reduction is possible if this kind of equipment is applied worldwide? What promotion is possible?

- Which product fits the market best? What does the market expect?  
After comparing an existing or planned new product with those of the competitors, potential new functionalities can be derived for the final new product.

But before taking the final decision, further questions should be answered:

- (a) In which growing markets and with which service can the product be placed?
- (b) Does the product fit with general trends, like energy reduction, less hazardous substances or less waste?

### **Explanation**

An interesting example is the trend toward "megacities". This trend creates a potential new target group of customers who will demand better energy efficiency, more networks, cooperation between products in a system, a focus on installation, mobility, a need for environmental protection, and, as always, a low enough price. Would the new product fit into such a trend? If not, perhaps the company should change its mission, for example, from a simple switch producer to a company selling everything connecting people in a megacity. Such a new business model could be much more compatible to the environment and could offer new business opportunities.

- (c) After the evaluation of alternatives, a rough estimate of a favorable solution might be possible. From that, the environmental part of the product profile should be derived and given as an input to the overall profile.

Some questions to consider:

- Which is the environmental part of the product profile?
- Describe the necessary attributes and functionalities of a product.
- Where are the competitors?
- Which values should be reduced and how much?
- Which attributes belong to which part of the life cycle?

Answers to these will provide a list of required attributes and services. A cross-check should find contradictions with other requirements such as technical features or target costs.

- (d) What should be delivered by suppliers as additional support? Proof of an environmental management system and absence of environmental and other risks is needed. Suppliers should especially develop components with very low energy consumption. Similar kinds of information on compatible software should be provided to suppliers, such as a list of materials or required properties. Cooperation on reuse, including testing of components, could be contracted.
- (e) Is your management system up-to-date? Many new tasks need to be managed, from Ecodesign to the management of risks. Start with a list of new tasks and corresponding processes. All missing pieces should be described and evaluated to determine what is really required and how the missing pieces are to be integrated into the company's systems.