Sustainable Design Series of Delft University of Technology

Eco-efficient Value creation

sustainable strategies for the circular economy

Joost G. Vogtländer

Co-authored by A. Mestre, R. van der Helm, A. Scheepens and R. Wever

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The cover photo is the Endeavour, a J-class ship originally built in 1934 for the America's Cup. The ship has been restored by Royal Huisman in The Netherlands. The ships of Royal Huisman are extreme examples of eco-efficient value creation: unique custom build yachts, exceeding all expectations. These classic and modern yachts have such a high quality that they are expected to last well over 100 years, kept in an excellent condition by good maintenance.
Sailing boats in general have a very low eco-costs/value ratio. They combine low eco-burden with a high value for the ship owner and the passengers.

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Joost G. Vogtländer

Co-authors:

Ana Mestre

Rosan van der Helm

Arno Scheepens

Renee Wever

Sustainabile Impact Metrics

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Preface

"The ever growing economy seems to be one of the major root-causes of the continuing deterioration of our environment. The question is: what can be done? Stopping the economic growth around the globe seems no realistic option, so the solution must be found in a better eco-efficiency of our systems for production and consumption (decoupling of economy and ecology). Future products and services need to have a high Value/Costs Ratio combined with a low burden for our environment. This is the challenge for modern designers, engineers, business managers and governmental leaders." This quotation was the start of the preface of my book "LCA-based assessment of sustainability: the Eco-costs/Value Ratio (EVR)" [1].

Most people who got acquainted with the EVR since its introduction in 1999, realized that the two dimensional approach of this model is a powerful way to design 'green' products and services ('eco-efficient value creation') and to determine a sustainable product portfolio strategy. However, it appeared that the 'translation' of the theoretical concept of the abovementioned book to innovative solutions is often too difficult.
To bridge the gap between theory and practice, two issues are essential:

- a relative simple way to calculate the 'eco-costs' (by means of 'Fast Track' LCA)
- good understanding of the meaning of 'value' in the equation

When I realized that calculation of the eco-costs was a problem in practice, I decided to write the "Practical Guide to LCA" [2], starting with the common sense, and building on it with practical solutions for, sometimes, complex issues (like recycling). Together with the LCA DATA book [3], and with extra Excel look-up tables at the website www.ecocostsvalue.com, calculations on the eco-costs of products and services have become quite easy and can be done in hours rather than months.
The second issue (understanding the meaning of value), however, appeared to be another hurdle in the application and understanding of the EVR model. The concept of the Customer Perceived Value (which is "the fair price in the eyes of the customer", or, "the use and fun that is expected after the purchase") of the *individual customer* is important for a full understanding of the strategic design consequences which follow from the EVR. This book deals with this second issue, shows how to enhance value, and gives many practical examples of eco-efficient value creation.
The third issue is related to the quest for solutions in the so called "circular economy" [5]. The notion that materials in the "technosphere" must be recycled, and that materials from the "biosphere" provide new opportunities for innovations, is not new. New is, however, the focus on the *transition* from the old, linear, systems towards new, circular, systems. Essential for such a transition is that new business models must be developed to support the transition. These business models must have extra added value (in comparison to the competition in the market) combined with lower eco-

burden (less resource depletion as well as less environmental pollution).

This book is not about the general philosophy of the circular economy as such, but about the practical implementation of it. Literature on the general philosophy is abundantly available, but my experience is that most of the students at our University, and many entrepreneurs and business managers, struggle with the practical design and implementation of sustainable innovation. Key questions are: 'is my new system really better for the environment than the existing systems?' and 'how do I add extra value to cope with the extra costs?'. I realised that the two dimensional approach of the EVR model provides the key to these two questions, but that 'the devil is in the detail'. I also realised that design and implementation of the circular economy is not about magic solutions but about common sense. But common sense is often not common practice. To tackle this issue requires an open mind, free of dogmas. However, it requires also a profound knowledge of 'design for sustainability' and 'market value' of products and services.

The design of innovative circular business systems is a matter of Eco-efficient Value Creation. This book is a comprehensive description how to accomplish that. The book starts with underlying principles and simple examples on products, gradually exploring more complex systems like regional Product Service Systems. Finally the book gives advice on corporate marketing and communications, supply chain management and investment strategies.

My hope is that this book will not only be used by students, but also by designers, architects, and business managers (and their consultants), since they all need a practical guide to assess and improve the sustainability of their innovative ideas.

Delft University of Technology, the Netherlands, September 2014
Joost G. Vogtländer

Contents

1 Introduction

1.1 A mission to accomplish

In November 1993, the World Council for Sustainable Development, WBCSD, defined a general mission statement for their member companies. See Fig. 1.1.

> "The delivery of competitively priced goods and services
> that satisfy human needs and bring 'quality of life',
> while progressively reducing ecological impacts
> and resource intensity, throughout the lifecycle,
> to a level at least in line with the earth's
> estimated carrying capacity" (WBCSD, 1995)

> "What we need now is a new era of economic growth – growth that is forceful
> and at the same time socially and environmentally sustainable."
> (Brundtland, 1987)

Figure 1.1

The mission to accomplish: two mission statements

This business oriented definition of the WCDB links two aspects of good governance:

- modern management practice ("the delivery of competitively priced goods and services … quality of life")
- the need of a sustainable society ("while progressively reducing …… to …… earth's carrying capacity").

The first part of the sentence asks for a maximum Value/Costs Ratio of the business chain, the second part of the sentence requires that this is achieved at a minimum level of ecological impact.
But what does this rather philosophical definition mean to business managers, designers and engineers in terms of the practical decisions they take? There is a need to resolve simple questions like: what is the best product design in terms of ecological impact?, what is the best product portfolio in terms of sustainability?, what is the best sustainable strategy?

It is now widely recognised by economists that the goal of sustainable development is principally an equity issue. Sustainable development is a requirement to manage the resource base, so that the average quality of life we ensure ourselves can potentially be

shared by all future generations. High levels of eco-efficiency of product-service systems are required to achieve such an 'intergenerational equity'.
However, there is also the awkward question of the equity within our own generation: the 'intragenerational equity', which is related to the sustainability issues with regard to the poor countries of our world.

The need for a better organised economy, decoupling the economic growth and the environmental degradation, was expressed for the first time in the Brundtland Report "Our Common Future" (1987, Preface, page xii), as the conclusion of a study on the situation in the developing countries:
"The downward spiral of poverty and environmental degradation is waste of opportunities and of resources. In particular it is a waste of human resources. These links between poverty, inequality and environmental degradation formed a major theme in our analysis and recommendations. *What is needed now is a new era of economic growth - growth that is forceful and at the same time socially and environmentally sustainable.*"
This statement is fully in line with the famous definition of sustainable development in this report (page 43): "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".
Both statements underline the need for eco-efficient value creation in a circular economy.

1.2 The Triple-P model

In line with the way of reasoning of the previous section, sustainability is often described in terms of the Triple-P model.
The term Triple-P is related to the aim of companies, and therefore it is related as well to the design of products and services. It refers to the concept of the "triple bottom line" as formulated by John Elkington in his book Cannibals with Forks. See Fig. 1.2.

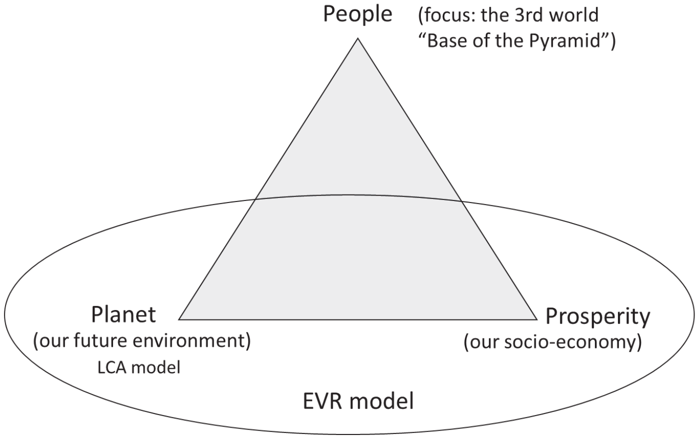


Figure 1.2

The Triple-P model for sustainability and its relationship with LCA and the EVR model

According to the triple bottom line concept, equal weight in corporate activities should be given to the following three aspects:

- 'People', the social aspects of sustainability (the 'intragenerational equity')
- 'Planet', the ecological consequences
- 'Profit', the economic profitability of companies (being the source of 'Prosperity')

The main point is that the 'bottom line' of an organization is not only an economic-financial one: an organization is responsible to its social and ecological environment as well. From this Triple-P perspective, an organization that considers a strategy of sustainability needs to find a balance between economic goals and goals with regard to the social and ecological environment.

The idea of the 3 dimensions originated from the Brundtland Report. In literature, the P of People is blurred by the notion that Western companies should take care of their own employees (in 'good governance'). It should be realised, however, that the P of People (in terms of sustainability) is primary related to the people of the developing countries (a matter of fair global distribution of Prosperity, at fair labour conditions), as explained in the previous section.

The original idea is that companies (and designers) must take well balanced decisions on the 3Ps: it is considered as a matter of trade-off, and therefore it is a matter of dilemmas. These dilemmas are of a double nature:

- long term versus short term (Planet is long term, Profit is short term)
- "they" versus "us" in terms of the distribution of Prosperity (the People of the Bottom of the Pyramid versus us in the Western World)

The model of the Eco-costs/Value Ratio (EVR) unravels the system of the 3 P's, primarily analysing carefully the P of Prosperity (expressed in 'value') and the P of Planet (eco-burden, expressed in 'eco-costs'), and analysing the interaction of these 2 P's in the our socio-economic system.

The third P of People (of the developing world) is of an extreme complex nature. Therefore, the interaction of the P of People with the other two P's is less developed in the EVR model. However, the EVR model provides some answers on how to give the developing countries a better share in our Prosperity and how to provide them with more money to reduce local environmental pollution.

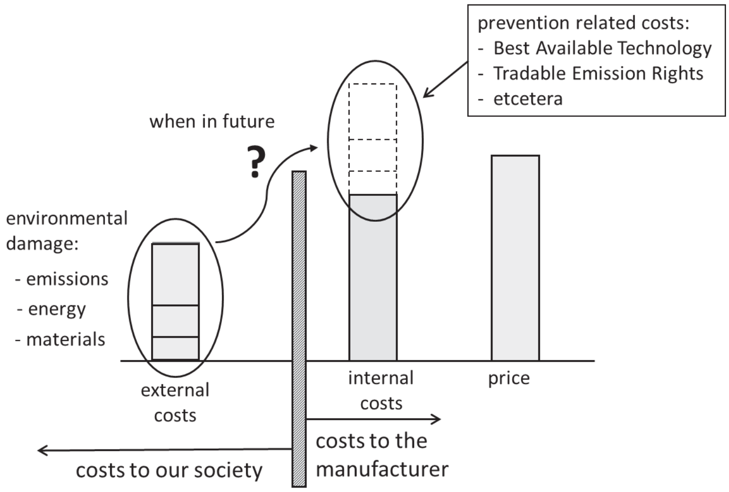
Although the original idea of the Triple-P model was to make the right trade-off in decision making, a more challenging way to approach the sustainability problem is not in terms of "or", but in terms of "and", as explained in the Section 1.1. One of the key elements of eco-efficient value creation is that innovative products should have low eco-burden as well as high value (both scoring better than the existing design solutions). Brundtland as well as the WBCSD mentioned decades ago that the key to sustainability is the decoupling of the economy and the ecology: products and services must have a low Eco-costs/Value Ratio.

1.3 The Three Stakeholders Model and prevention costs

Companies are facing the slow but inevitable 'internalisation' of environmental costs. Internalisation means that the damage costs of pollution of products are to be transferred to the internal costs of the manufacturer. At this moment the manufacturing costs do not cover the environmental damage which is caused by the production, use and end-of-life of a product. This "pollution is for free" mentality of companies is less and less accepted by the society in general.
The trend of internalization is slow but relentless. It is depicted in Fig. 1.3

Figure 1.3

Environmental burden will gradually become internal costs as a consequence of governmental regulations; the question is not if but when



It is important to understand the main mechanism behind this trend towards a (more) sustainable society. What is the main driver behind the internalization of the external damage costs, and what are the strategic consequences for companies?
More in general: what mechanisms in society make that we have progress in the field of sustainability and what mechanisms seem to fail to have a major contribution so far?

The three stakeholders model [1, Appendix 8] has been developed to describe and understand the interaction between customers/citizens[1], governments and companies on the road towards sustainability. See Fig. 1.4.

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[1] In the model of this book every individual has both sides: the behaviour as a consumer and the social responsibility as a citizen. Consumers tend to behave as individualists triggered by modern marketing, looking for the best quality/price ratio at the moment of a purchase in a shop. As citizens people have a more conscious and responsible attitude, and have a more long term view, thinking about the future. The EVR model is based on a combination of two paradigms of Appendix X: the individualistic paradigm and a democratic-hierarchical paradigm of sustainability.

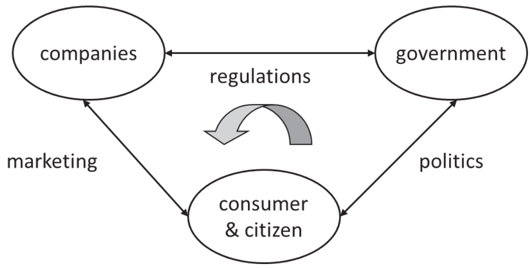

Figure 1.4

The three stakeholders model

In the transition towards sustainability, each of the three stakeholders has to play its own role:

- the people (as consumers and as citizens) have to shift their expenditures towards a lower eco-cost per euro spent money (a lower EVR), i.e. they should transform their consumption pattern towards 'green' products and services
- the companies have to create product-service combinations with a lower eco-burden and higher value, i.e. they should offer attractive 'green' solutions to the market
- the governments have to create regulations and new systems for tax, subsidies and Tradable Emission Rights, i.e. they should create a business environment which gives 'green' solutions a fair chance in competition with the current products and services ("level the playing field")

It is obvious that, when one of the stakeholders fails to play the right role, the transition towards sustainability will not happen. What triggers each of the stakeholders of the system to go in the right direction? Who triggers the transition process?

The key to the solution of the problem is to realize (and accept) that the instinct of the vast majority of consumers is individualistic, reacting instantly and in the short term to offerings on the market. In a shop, the vast majority of consumers is not prepared to pay more for the fact that a product is sustainable, because of two reasons:

- they tend to think only about short term benefits at the moment of the purchase; a long term, complex, and ‘far-away’ issue like sustainability is not part of the rather impulsive and intuitive buying process
- even when they think about sustainability, most people are not altruistic: they are not prepared to pay extra when other people don’t

However, each consumer is a citizen as well. The citizen realises at home that sustainability is a long term issue. Most people have the opinion that Mother Nature must be preserved for our children and grandchildren. Since this is considered as a long term, global issue, citizens think that they should act together in a well-coordinated way.

This leads to a **counter clockwise** direction of interactions in the triangle of Fig. 1.4:

- the citizens are interacting with their governments via politics: citizens want to have a sustainable future; they are aware of the fact that the required transition can only succeed when we put our shoulders under it together, and therefore ask the government to take action
- the government is interacting with the companies: governments take actions via regulations, taxes, subsidies, agreements with business sectors (Dutch: convenant), etc., and force companies to react; companies accept governmental measures, as long as there is a 'level playing field ' (= all companies have the same restrictions)
- companies are interacting with consumers: companies try to offer consumers 'best quality for money' and gain market share by satisfying the (short term) customer (individual) needs

In this way, the customer can buy what is on the shelf. There is no need to bother at that moment about sustainability. The consumer knows also that there are no 'free riders'. In the last two decennia, the main environmental progress has been made by this mechanism: only when governments do something, companies do act[2].
In some business areas, industry is acting pro-actively (instead of reactively), for instance in the automotive industry. In those areas, one is trying to gain a competitive edge by being the first to meet future governmental standards.

A consequence of the described 'counter clockwise' mechanism of Fig. 1.4 is that the 'external environmental damage' in Fig. 1.3 will be transferred to the companies in an *indirect* way. It is not expected that companies will have to pay for the damage caused by their products, but it is expected that they are forced to comply with stricter regulations (e.g. applying the Best Available Technology, BATNEC) or are forced to reduce emissions in an indirect way (e.g. by a system of Tradable Emission Rights, TAR). **So the external damage costs are 'internalized' by adding prevention costs on top of the existing, internal, costs of the manufacturer.**
When the total emissions of the society become below the no-effect-level[3] by prevention measures, the mechanism of internalization will stop. The 'eco-costs' are the marginal prevention costs of the most expensive measures to achieve this no-effect-level in the most efficient way. These eco-costs are currently for the manufacturer the 'costs of future non-compliance with sustainability' (future BATNEC and/or TAR costs). Eco-costs can be considered as 'hidden obligations' to our society: when all companies take preventive measures up to the level of the eco-costs, the pollution problem is expected to be solved. For a further description of eco-costs (as a single

[2] Apart from sustainable market niche players, and apart from the results of Total Quality Management type projects where reduction of cost goes often hand-in-hand with reduction of eco-costs. Both, however, have a quite limited contribution to the big transition which is required.

[3] The no-effect-level of CO_2 emissions is the level where the emissions and the natural absorption of the earth are in equilibrium again at a maximum temperature rise of 2 ^{0}C. The no-effect-level of a toxic emission is the level where the concentration in nature is below the toxicity threshold (most natural toxic substances have a toxicity threshold, below which they might even have a beneficial effect), or below the natural background level. For Human toxicity the no-observable-adverse-effect-level is used.

indicator for Life Cycle Assessment, LCA), and the way the eco-costs are calculated from the prevention costs curves, see Appendix I.

The strategic relevance of the aforementioned mechanism is that products with a high eco-burden will have the risk, in future, that the total costs are getting higher than the price. The profit margin will vanish then, and such a product will disappear from the market, see Fig. 1.3.
When a company reduces the eco-burden of its products pro-actively, it will reduce its eco-costs. Such a company has a better competitive position in future.

So the three stakeholder model has a high relevance in relation to the design of products, and business strategies. It explains the meaning of eco-costs in terms of practical consequences for business people.

The **clockwise** direction in the three stakeholder model of Fig. 1.4 (changing the consumer - business relationship) is the dream of most environmentalists. However, the required shift of buying behaviour didn't seem to happen for the majority of consumers so far for the aforementioned reasons (the short term benefit buying behaviour, and the lack of altruism).
So the impact of the clockwise direction on the progress of a transition to a sustainable society tends to remain quite limited:

- Willingness to Pay.
  Only a small market niche of people (3%-6%), buys a 'green' product at a more than 10% higher price. It seems extremely difficult to convince more people that they should buy 'green' even when the price is higher.
- Boycotting.
  In some exceptional situations, pressure groups have been able to trigger consumer boycotting actions, which forced companies to shift their environmental policy (e.g. Shell in the case of the Brent Spar; some products of Sainsbury). This can happen only under special conditions [4, page 133, footnote 42], and therefore cannot be regarded as the standard road towards sustainability.
- Reputational Risk.
  An important mechanism, which will probably gain more importance in the near future, is related to the powerful communication opportunities of internet (Twitter, YouTube, etc.). Companies are aware of the impact which social media can have on their image. They are aware of the risk of damage to their brand names if their behaviour is unsustainable. The fear for that risk is driving many big companies to more environmental care.
  Note: There is a difference between boycotting and the mechanism of reputation damage. In the case of boycotting, buyers are asked to change their buying behaviour. In the case of the mechanism of reputation risk, companies are asked to change their unsustainable behaviour.

- Green Labelling and brand image.
  Green labelling is an attempt to influence the green buying behaviour of the customer. It should work in situations where the price of the standard and the green product is the same. This situation is described by the 'double filter model' (see Section 8.1): when the customer cannot decide on basis of quality/price ratio, the sustainability issue will help to make the final choice. In the current practice, however, green labelling is not very successful yet. The reason is threefold:
  - market players seem to be unwilling to agree on standards for green labelling, which results in a wide variety of labels
  - consumers distrust labels since they think that green labels are used by companies for 'green-washing' of their products[4]
  - consumers distrust the quality of the product when a green product has the same price as the standard products ("the extra costs to make a product green must have been compensated by less quality")[4]

  Enhancing the corporate image or sector wide brand reputation[5] with regard to sustainability seems to be a more promising strategy to promote green market segments, than labelling of individual products.

The conclusion is that there seems to be no simple solution for a quick jump into sustainable product markets just by introducing 'green value'. The road towards a sustainable future seems to be more complex.

The transition towards a circular economy will certainly help to resolve the problem of materials scarcity as well as environmental pollution. The issue, however, is not that such a transition can resolve the problem, the issue is how to accomplish such a transition. The issue is not that we need new, innovative, products and business models (everybody will agree on that), but the issue is how to design and implement them.
The model of the Eco-costs/Value Ratio tries to unravel the complex relationships between eco-costs and value, and tries to provide solutions for the design and marketing of products. This book provides many practical examples, starting with relative simple design cases, and ending with complex strategic issues.

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[4] Two quick-and-dirty enquiries under approximate 300 bachelor students (by raising hands in a lecture on sustainability) indicated the following:
At the question "suppose you see two identical Diesel trousers in a shop, the same price, who takes the product with the green label", only 50% would take the trouser with the green label, 25% don't do that because they distrust labels (and therefor boycott it), and 25% don't do that because they don't trust the quality of green products.
When the above question is changed by adding "……. and assume that you are sure that the quality is the same, and you trust the sustainability claim", nearly 100% respondents take the product with the green label. At a 5% higher price, only 50% will still buy the green product. At 10% higher price less than 4 % buyers are left.

[5] Examples of successful brand labelling are FSC wood, MSC fish, and UTZ coffee. The key to success seems to be a sector wide approach, where several leading companies in the product chain and NGOs work together to create a credible solution

1.4 The structure of this book

Section 2 of this book introduces the model of the Eco-costs/Value Ratio, EVR. It is assumed that the reader knows the background of the eco-costs (a so called single-indicator in LCA, see Appendix I), and knows how to calculate it [2[3]. The value is defined in this section as the market price.
The basic strategic consequences of the EVR for companies are explained, the aspects of consumer behaviour in relationship with macro-economic consequences are analysed, and the so-called rebound effect is explained. At the end of this section, the consequences for product design are given: the so called 'double objective' in 'eco-efficient value creation'.

Section 3 and Section 4 are cases of eco-efficient value creation in packaging design, respectively design of high-end products made out of cork. Section 3 shows how the theoretical approach can be applied in practice, and shows the effect of materials recycling in packaging solutions. Section 4 gives a step by step design method, applied to a renewable material (cork).

Section 5 explains why the EVR is about 'value' instead of 'price' or 'costs'. This section explains the meaning of Customer Perceived Value (CVP) and Willingness to Pay (WTP) of individual customers, and the relationship with the market price of products. It shows that a company cannot increase a price level without improving the value of a product, and it shows how value can be enhanced

Section 6 is about the business model concept of a Sustainable Product Service System (SusPSS). It shows that the business concept of a normal PSS is successful in cases where the service is added to enhance the value of the product. Similarly a SusPSS is successful when the value of a sustainable product is enhanced by adding a service.
It is a widespread misunderstanding of environmentalists that the concept of a SusPSS can be used to reduce the eco-burden of a 'dirty' product. In other words:

- a SusPSS can successfully be applied to enhance the value of a 'green' product (it often is an indispensable concept in the marketing of green products)
- a SusPSS is hardly successful in converting a dirty product to green (a dirty product with extra service to sell it in the market has an adverse effect in terms of sustainability)

A case is provided at the end of this section, with the analysis of a regional PSS- type circular system. Reference is given to a Circular Transition Framework (see Appendix XII) that shows the complex governmental interactions, which are needed for the required transformation towards a circular economy.

Section 7 and Section 8 show how methods and tools from management science relate to the EVR model of Eco-efficient value Creation. Section 7 provides some tools for designers and business managers to enhance the value of a product whereas the costs of a product are reduced at the same time. This is done by understanding the different aspects ('dimensions') of quality and its relationship to Customer Perceived Value, in combination with the reduction of "wastage of quality" (Value Engineering). This section also deals with the marketing strategy of quality products. Section 8 is about 'green marketing': the problems and pitfalls, as well as the opportunities in marketing of green product brands. This section is about successful strategies and gives a case on the market communication of a 'green' shoe.

Section 9 is about sustainable business strategies. It is about the awareness of business opportunities, sector analyses and strategies (each business sector has a different opportunity), investment and disinvestment strategies, timing of implementation, and strategies in supply chain management.

The Appendices deal with:

- *general topics*: eco-costs (what is it); LCA (how do you do it); benchmarking of sustainable products (Appendix I, II and III)
- *design tools*: the LIDs wheel (its application in eco-design); application of the EVR Decision Matrix for eco-efficient value creation; the Circular Transition Framework; Pareto Optimal selection of design solutions (Appendix IV, V, VI, and VII)
- *special issues*: the rebound effect in domestic energy conservation; the EVR of waste, recycling, and re-use of product components (Appendix VIII and IX)
- *understanding the 3 paradigms in sustainability*: the Egalitarian, the Hierarchist, and the Individualist (Appendix X)
- *business framework of strategic focus and operational actions:* the "Environmental Business Strategy Framework", describing the differences in strategic actions for different types of companies (Appendix XI)

2 Eco-efficient Value Creation

2.1 The eco-costs/value ratio (EVR) of products and services

The method of eco-efficient value creation is based on the model of the Eco-costs/Value Ratio, EVR. The EVR is depicted in Fig. 2.1, which shows that a product model has 3 dimensions: eco-costs, costs, and value.

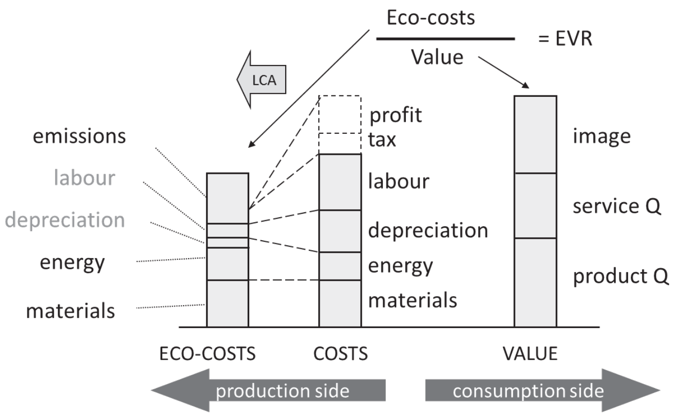


Figure 2.1

The three dimensions of a product and/or service: the eco-costs, the costs and the value. Note: In Section 2, 3, 4 and 6 the value is the market price

The eco-costs are determined by LCA, the value is the market value, determined by the Customer Perceived Value (the 'fair price' in the eyes of the customer, the Willingness To Pay). **In this section, and in Section 3, 4 and 6, the value is assumed to be equal to the market price of an existing product, or the expected market price of a product which is still in the development phase**[6].

The EVR has a much wider background than "just dividing the eco-costs by the value". This ratio appears to be the crucial factor in a sustainable society, since it combines the sustainability aspects of both the production side (eco-costs) and the consumption side (value):

[6] The expected market price can be determined by asking potential customers about their Willingness to Pay (WTP) in an enquiry. The WTP is different for each individual, so an enquiry on the WTP does only make sense when it is restricted to a certain group of people (a market niche). The expected market price is related to a certain percentage of potential buyers in the market niche, i.e. people who indicated that their WTP is above the assumed future market price. The issue of purchasing behaviour of individuals is elaborated in Section 5 and 8.

- The EVR is an indicator to reveal sustainable and unsustainable consumption patterns of people. Example: When somebody spends 1000 euro per month on housing (in Europe: EVR approx. 0,3) it is less harmful for the environment than when 1000 euro is spend on diesel (in Europe: EVR approx. 1,0).
  This issue is dealt with in the next section, Section 2.3.
- The EVR is also an indicator that reveals the risk of 'unsustainability' for the manufacturer. Products with a high EVR run a considerable risk in future that the production costs become higher than the market price, as described in Section 1.3
  This issue will be elaborated in Section 9.

The basic idea of the EVR model is to link the value chain of Porter[7], to the ecological product chain. In the value chain, the added value (in terms of money) and the added costs are determined for each step of the product life, cradle-to-grave. Similarly, the ecological impact of each step in the product chain is expressed in terms of money, the eco-costs. See Fig. 2.2.

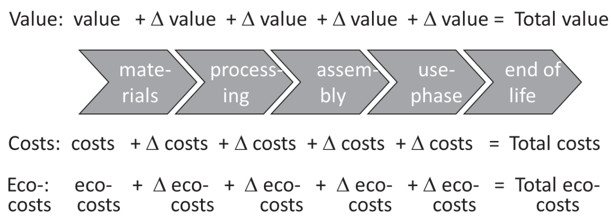


Figure 2.2

The basic idea of the EVR: combining the value chain with the ecological chain

The eco-costs and the value in the chain can preferably be depicted in a two dimensional graph, see Fig. 2.3.

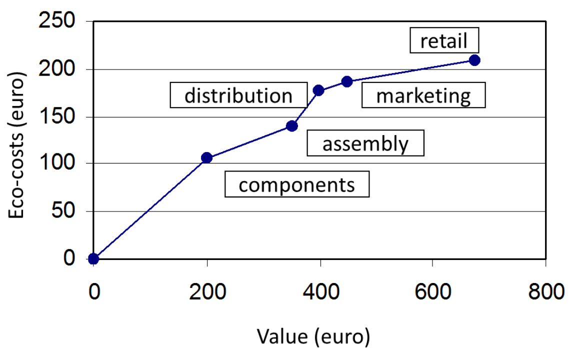


Figure 2.3

The two dimensional representation of the EVR of a product, cradle-to-gate

[7] Michael Porter is one of the leading scholars in management science. He introduced in 1985 the idea of the value chain: each step in a production chain adds costs, but also adds value. Analysing the Value/Costs Ratio in each step reveals how the total Value/Costs Ratio of a product-service combination can be improved. **Note that there exists also a Porter chain from the right to the left in Fig 2.2, starting with waste and adding value by recycling. In this way the Porter chain becomes circular.**

Note that the example of Fig. 2.3 shows the chain only cradle-to-gate (= the retail shop). According to ISO 14044 this is only allowed when the use phase and the end-of-life phase have a negligible effect on the total eco-costs [2, Appendix III]. In the EVR model this is only allowed when both eco-costs and costs (price) for the user are negligible in these phases. **The use phase must always be included when the product requires energy in the use phase. The end-of-life phase must always be included for systems with eco-costs credits [2, Section 5], either for closed or open loop recycling systems, or for combustion with heat recovery of bio-based materials (wood, bio-based polymers, etc.). See also Appendix IX.**

2.2 The EVR in relation to sustainable product strategies for companies

In Section 1.3 it was explained that the eco-costs of a product are relevant for business strategies, because companies are facing the trend in society that people do not accept anymore that companies pollute the world free of charge. The current 'external' environmental damage is expected to be 'internalized' in the costs structure of a product (by tax, Tradable Emission Rights, obligatory Best Available Technology, or other governmental regulations). This process is slow but relentless, and will be driven by the political will of citizens to implement stricter governmental regulations. Eco-costs will then become part of the internal production costs.

This internalizing of eco-costs might be a threat to a company, but it might also be an opportunity: "When my product has less eco-burden than that of my competitor, my product can withstand stricter regulations of the government." So the characteristic of low eco-costs of products is a competitive edge in the future.

To analyse the short term and the long term market prospects of a product or a product service combination (Product Service System, PSS), each product can be positioned in the product portfolio matrix of Fig. 2.4.

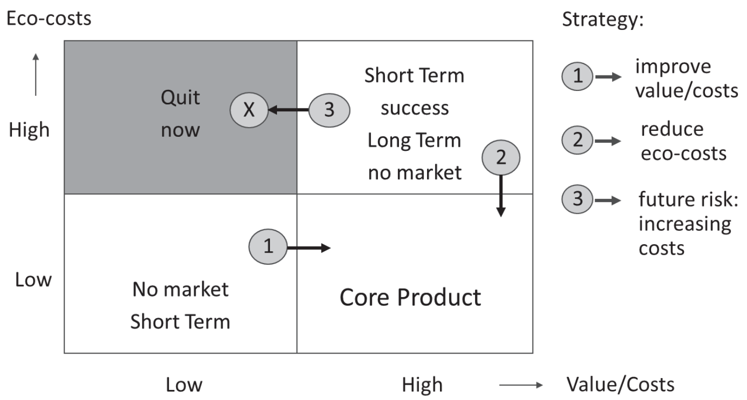


Figure 2.4

Sustainable Business Strategy Matrix for products of companies

The basic idea of this portfolio matrix is the notion that a product, a service or a PSS is characterized by:

- its short term market potential: high Value/Costs Ratio
- its long term market requirement: low Eco-costs.

The high Value/Costs Ratio gives the opportunity for a company of making high profits (by a high profit margin per product and/or by a high market share). Low eco-costs make that the good position in the market will not deteriorate in future by stricter environmental regulations and higher material prices. So the lower right quadrant in the matrix is the desired position.

In terms of product strategy, the matrix results in 3 strategic directions:

1. enhance the Value/Costs Ratio of a green design to create a bigger market
2. lower the eco-costs of current successful products to make it fit for future markets
3. abandon products with a low Value/Costs Ratio (not much profit, small market) and high eco-costs

For many 'green designs', the usual problem is that they have a low current Value/Costs Ratio (the lower left quadrant). In most of the cases the production costs are higher than the production costs of the classic solution; in some cases even the (perceived) quality is poor. There are two ways to do something about it (arrow 1 in Fig. 2.4):

- enhance the (perceived) quality of the product (see Section 7)
- attach a service to the product (create a PSS) in a way that the value of the bundle of the product and the service is more than the value of its components (Section 6 of this book will provide examples on how to do this)

For most of the current products, the Value/Costs Ratio is high, but the eco-costs are high as well (the upper right quadrant). Doing nothing is no option: it will cause that products drift into the upper left quadrant (arrow 3), because of the aforementioned 'internalization' of costs of pollution. Such a product will be forced out of the market, since the sales price of the product cannot be increased above the fair price in the eyes of the customers. These products and its production processes have to be redesigned to lower the eco-costs (arrow 2). In practice there are plenty of opportunities to lower the eco-costs at even a higher value by a better choice of materials, by recycling, and by saving energy.

The greening of products of existing companies is far more promising for a fast transition towards sustainability, than start-up of new companies with new green products. There are two reasons:

- in a vast majority of cases there are many opportunities to make existing products more sustainable, or to replace them by better product service systems

- existing large companies have economies of scale for production and distribution, and have an existing client base, brand name, quality standards, and service systems, which can be used for marketing

This means that big companies have a moral obligation to our society to accelerate the greening of their products.

Note: The most common fear of business managers is that their new green products end up with a deteriorated Value/Costs Ratio, and hence will have a cumbersome position in the market. The stability of the governmental policy plays an important role here. When governmental regulations which level the playing field are postponed or even abandoned, proactive companies with sound product strategies are harmed. This can cause severe damage to the transition process and may lead to reluctance of players to move proactively in the future.

The most successful design options of the EVR model are depicted in Fig. 2.5. In general, the EVR is getting better with less material and more labour. The best design strategy is:

- to increase value where value is high (more quality, service, life span, and image)
- to decrease the eco-costs where the eco-costs are high (a shift to bio-based materials, recycling and renewable energy)

Appendix IV provides a checklist on the reduction of eco-costs. Section 6 and 7 give examples on how to enhance the value.
The importance of the end-of-life solution is clearly depicted in Fig. 2.5. Landfill reduces the value of the total system, and leads to higher eco-costs. Recycling (as well as re-use and remanufacturing) results in an added value combined with lower eco-costs ('end-of-life credits' in LCA). Fig. 2.5 clearly shows that the transformation towards a circular economy fulfils the 'double obligation' of 'eco-efficient value creation' as further explained in Section 2.5. However, it also shows that designing a sustainable circular system needs to address more than circularity only: other aspects as clean production, minimum transport and optimal marketing play an important role as well.

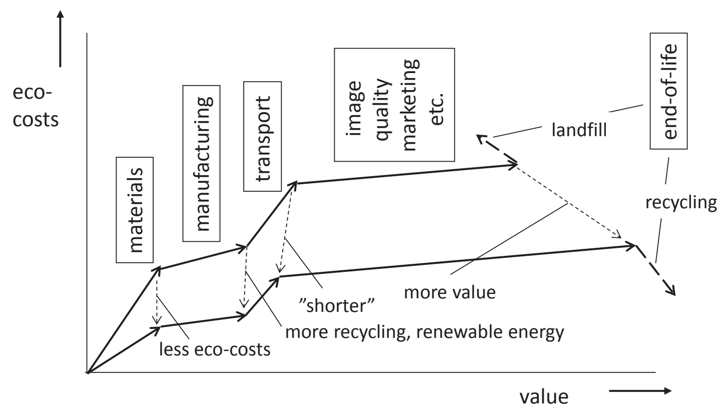


Figure 2.5

Design strategies to enhance the EVR of a product (for products with a negligible eco-burden in the use phase)

2.3 Consumer behaviour and decoupling

There is a consumer's side of the decoupling of economy and ecology. Under the assumption that most of the households spend in their life what they earn in their life (the savings ratio is <5% in most countries), the total EVR of the spending of households is the key towards sustainability. Only when this total EVR of the spending gets lower, the eco-costs related to the total spending can be reduced even at a higher level of spending. There are two ways of achieving this:

- at the production side: the improvement of eco-efficiency ('lowering EVR') of products and services by the industry
- at the consumer's side: the change of lifestyle of customers in the direction of 'low EVR' products.

At the production side, our society is heading in the right direction: gradually, industrial production is achieving higher levels of the Value/Costs Ratio and is at the same time becoming cleaner. At the consumer's side, however, our society is suffering from the fact that the consumer preferences are heading in the wrong direction when they get

Figure 2.6a

Expenditures in Dutch households in 1995, in euros of 2007.

Ranges of the columns:
1. poorest 25%
2. 15% - 50%
3. 50% - 75%
4. richest 25%

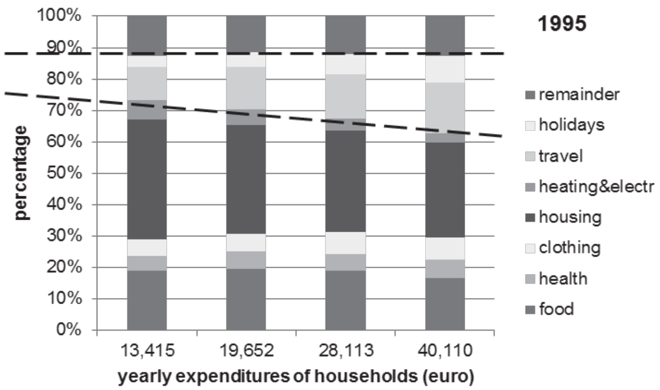
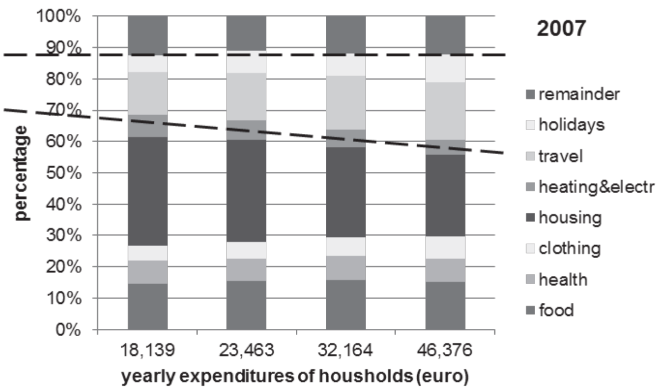


Figure 2.6b

Expenditures in Dutch households in 2007.

Ranges of the columns:
1. poorest 25%
2. 15% - 50%
3. 50% - 75%
4. richest 25%



richer: towards products and services with an unfavourable EVR (like driving in SUVs, driving more kilometres, intercontinental flights for holidays). See Fig. 2.6.
Fig. 2.6a and 2.6b show that people in The Netherlands, when they have more money available, spend relatively less money on housing and more money on cars and holidays. There is no reason to believe that this is different in other EC countries. Other studies show that people tend to have intercontinental holidays at the moment they can afford it. This shift in consumer spending is going in the wrong direction, since housing is less harmful for the environment than travel:

- the EVR of housing is about 0.3
- the EVR of travel (for commuting, leisure and holidays by plane) is about 0.8 - 0.9

The preference for traveling is becoming a big threat for the environment when the people in our world are getting richer.
A short macro-economic analysis on what happens in the European Union reveals what can be done. Fig. 2.7 shows the EVR (= eco-costs/price) on the Y-axis as a function of the cumulative expenditures of all products and services of all citizens in the EU25 on the X-axis. The data is derived from the EIPRO study of the European Commission (EIPRO = environmental impact of products).

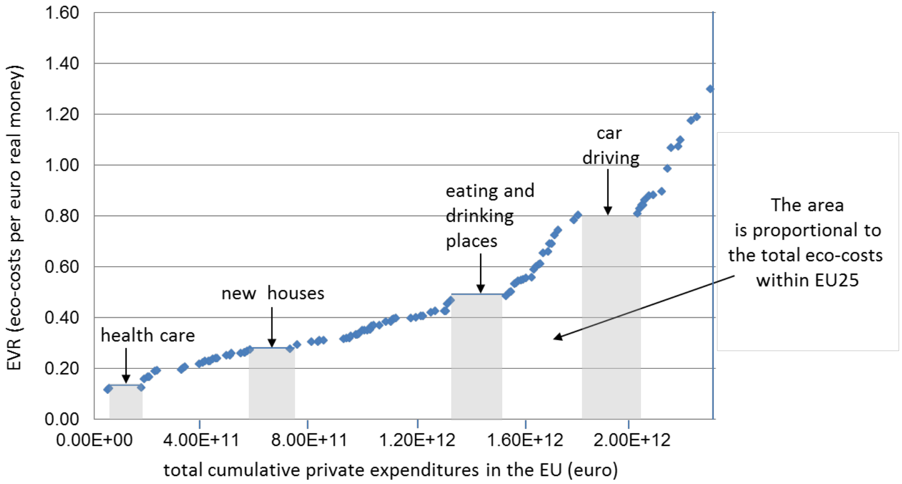


Figure 2.7

The EVR and the total expenditures of all consumers in the EU25 (from EIPRO)

The area underneath the curve is proportional to the total eco-costs of the EU25. Basically there are two strategies to reduce the area under the curve:

- force industry to reduce the eco-costs of their products (this will shift the curve downward), e.g. by cleaner and more energy efficient production, less transport, less energy in the use phase, closed loop recycling, et cetera
- try to reduce expenditures of consumers in the high end of the curve, and let them spend this money at the low end of the curve (this will shift the middle part of the curve to the right), e.g. tempt consumers to spend their money on health care and new houses, rather than on car driving

The question is now how designers and engineers can contribute to this required shift towards sustainability and what this means to product portfolio strategies of companies. In the next section we will look at the possible design alternatives of new products and explain the issue of the 'rebound effect'.

2.4 Design alternatives and the rebound effect

In Fig. 2.3, Section 2.1, the two dimensional representation of the EVR of a product was introduced. It can reveal the fundamental differences between two (or more) alternative designs. Two examples from the automotive industry are shown here to explain this in further detail, and to explain the rebound effect[8] which stems from consumer behaviour.

The first example is the reduction of fuel consumption by reducing the weight of a car. One of the strategies to reduce the environmental impact of cars throughout the lifecycle is the reduction of fuel consumption. This can be achieved by making cars lighter. See Fig. 2.8.

Figure 2.8

The reduction of the weight of part of the coach work of a car (data from Dr. Konrad Saur, PE Product Engineering GmbH)

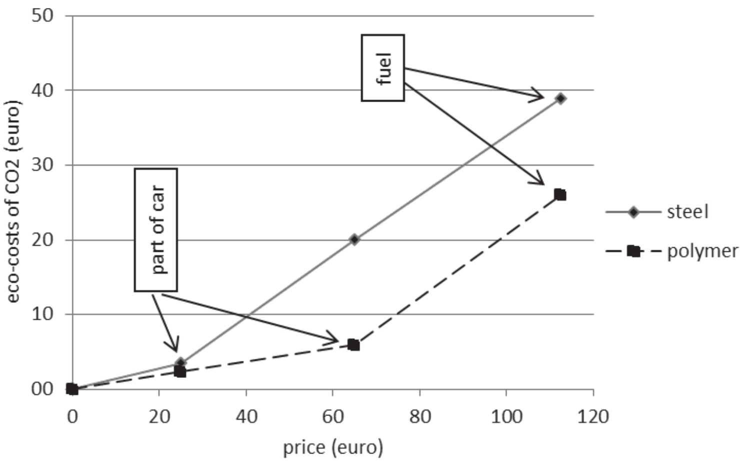


Fig. 2.8 shows the result of a calculation on the eco-costs, and the price, of a component of a middle class German car (a polymer or steel sheet of the coach work of an Audi). The left hand sides of the two lines relate to the production (the end-of-

[8] The rebound effect refers to increased consumption which results from actions that increase efficiency and reduce consumer costs (savings). For example, replacement of conventional light bulbs by low energy light bulbs that reduces consumption by 75% does not usually result in a full 75% reduction in energy consumption. This is because residents of the house find that they can afford to have more light in their home for a longer period (they even install light in their garden). As a result, they reinvest a portion of potential energy savings in additional comfort. The difference between the 75% potential energy savings and the actual savings is the rebound effect. For more background information, see Appendix VIII.

life phase included) of that specific part of the coach-work. The right hand sides of the two lines depict the fuel consumption related to that specific part of the coach-work (0.305 litre fuel per 100 km and 100 kg; the reduction of weight is approximately 45%).
At a total lifetime of 250,000 km, the solution with the polymer sheet is break even with steel sheet from the economic point of view (the economic savings on the fuel are equal to the extra costs of the coach-work), however, the solution with the polymer coachwork is much better from the environmental point of view, since it has lower eco-costs throughout the life cycle.

The second example is the reduction of the fuel consumption by a better aerodynamic design. See Fig. 2.9. It is an example of the rebound effect in the automotive industry.

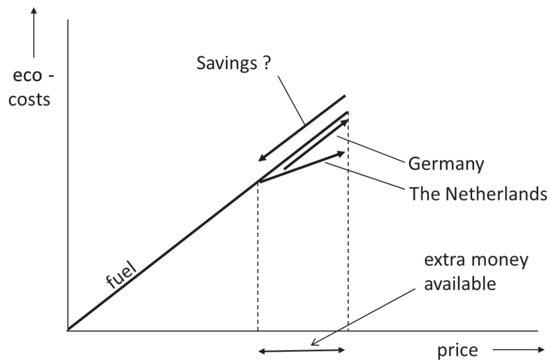


Figure 2.9

Reduction of the fuel consumption of a car by better aerodynamics; an example of the rebound effect

On first sight better aerodynamics is a win-win situation in the use phase, since it results in savings in eco-costs (at a high EVR) as well as a lower price for the fuel. The rebound effect, however, reduces the positive result in terms of sustainability considerably.
The rebound effect of this case can be explained by the consumer preference of spending money on travelling, as shown in Fig. 2.6. The money saved on fuel is spent again on fuel in a country with no speed limit, like Germany. The advantage of a better aerodynamics is transferred to driving faster (perceived as convenience and fun), instead of savings on diesel consumption (savings of eco-costs).
In The Netherlands, a country with speed limits, the situation is slightly better. It results in driving more. 'Driving more' has a lower EVR than 'driving faster' (the EVR of the diesel is higher than the EVR for the car+diesel), but the end result is that the savings in eco-costs are much less than expected.

The solution of the reduced weight of Fig. 2.8 does not have the rebound, and therefore is a better solution for sustainability.

Concluding: **sustainable products must have lower eco-costs, but at the same time higher value (market price), to avoid the rebound effect.**
See Fig. 2.10 in the next section.

2.5 Eco-efficient value creation and the double objective of designers

An important conclusion from the previous sections is summarised in Fig 2.10. It is the double objective for designers: creating products with a higher value and at the same time lower eco-costs.

Figure 2.10

The required direction of 'de-coupling': less eco-costs but more value. It is the double objective for designers

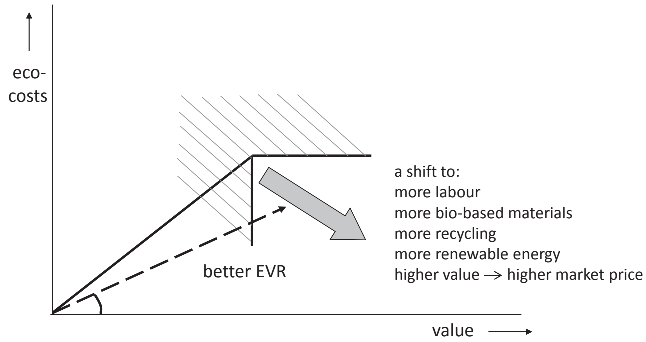


Fig. 2.10 is not only about the rebound effect: it depicts also the essence of the Brundtland report and the WBCSD mission statement as quoted in Section 1.1. It shows that care for the P of Planet and the P of Prosperity in the Triple-P model in Section 1.2 is not an issue of trade off (as proposed by Elkington). It is not an issue of 'or' but an issue of 'and'. The Bundtland report gives a vision on this issue in the Summary at page 6:
"Yet in the end, sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs."
The role of the designer (….orientation of technological development,….consistent with future as well as present needs….) is the subject of this section. In the EVR model the future needs are indicated by the eco-costs, the present needs are indicated by the value.
The way towards sustainability requires a 'double objective' of the designer of new products. Designers must create:

- **lower eco-costs, and at the same time**
- **higher value (a higher market price)**

We call this: 'eco-efficient value creation'.

Note that the EVR model has a lot in common with the C2C philosophy, which also emphasizes eco-effective solutions (less harmful materials, more recycling). However, the EVR model combines this philosophy with LCA and business science.

The reason we need to create extra value for eco-efficient products is threefold:

1. people do not buy products with a lower value (compared to products with the same functionality and quality)
2. a higher price in the market is required to cover the higher production costs of green products (note that a higher price is only accepted by the consumer when the perceived value is higher, otherwise the consumer will not buy the product)
3. a higher price prevents the rebound effect (it prevents expenditures at a higher EVR caused by the consumer preferences for driving cars, see Fig. 2.6 and 2.7.)

Below, two examples of eco-efficient value creation are given.

The first example is the introduction of the hybrid Lexus in the USA, see Fig. 2.11:

- the customer value has increased, by emphasising its combined power and comfort (from the advertisement in the US:
  "……While it may have a V6 engine under the hood, the extra boost from the electric-drive motor gives the vehicle the acceleration power of a V8……. and the noise levels in Lexus hybrid vehicles have been reduced even more")
- the eco-costs of driving are lower, since its excellent overall fuel economy

Figure 2.11

Better EVR of hybrid cars. Case the Lexus: better acceleration, less fuel

Note that it is **not** a good idea to reduce the acceleration in order to save eco-costs. The reason is, that a high acceleration of a car enhances the value considerably (high acceleration is associated with expensive sports cars like Porsche and Ferrari). On the other hand, most people who buy these luxurious cars hardly use its acceleration. For these people acceleration is more part of the image of the product than it is part of the product qualities they use on a daily basis. Therefore, high acceleration has a low EVR.

The second example is the introduction of Senseo, see Fig. 2.12, by SaraLee-DE (now D.E Master Blenders) and Philips Electronics.

Figure 2.12

Better EVR of the Senseo system: more convenience, less electricity

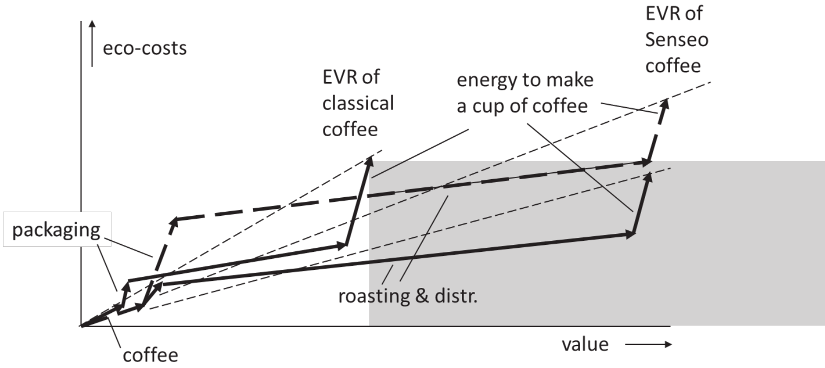
This is a perfect example of a design with an improved EVR:

- the customer value has increased (it is easier to make a cup of coffee), which translates in a higher price in the market (to cover the extra production costs of the system as well)
- the eco-costs per cup of coffee is less than for the conventional coffee, since heating of water is done efficiently, and is done in the exact amount (not too much of hot water, which is not used afterwards). Note that in the case of a classical coffee machine, an average of one third of the pot is thrown away in practice.

Fig. 2.13 depicts the effect on the eco-costs value chart for the classical coffee machine, the first design of the Senseo system, and a redesign with reduced eco-costs of the packaging to fulfil the 'double objective' criterion (the grey area).
Note that the eco-costs of the packaging of these modern 'single cup of coffee' concepts is an important issue in case users drink a lot of coffee.

Figure 2.13

The EVR of conventional coffee machine system, the Senseo system, and a redesign of the Senseo system which fulfils 'the double objective'



These examples show that it is often not possible to add value without increasing eco-costs at the level of the components of a product system. In Section 2.3, however, it was explained that adding value at low additional eco-costs is good for sustainability as such, from the macro-economic point of view.
On the other hand, lowering eco-costs at the cost of quality and price (value) is generally not good for sustainability, as it was explained in Section 2.4. Not only in regard with design and innovation of the product itself, but also in regard with the image of sustainable products in our society. Lowering the eco-costs at the costs of quality is damaging the reputation of green products (many people do not trust the quality of green apparel fibre, dislike recycled writing paper, etc.). This issue is explained further in Section 8.

The essence of the 'double objective' and 'eco-efficient value creation' is that the designer has to make clever combinations of components and/or sub-systems of the product. This aspect is shown in the case on cork design (Section 4).
For this reason it is necessary to do the EVR (and LCA) analyses at the beginning of the design (at the fuzzy front end).

It is important to understand the 6 directions of product design and system innovation, as shown in Fig. 2.14.[9]

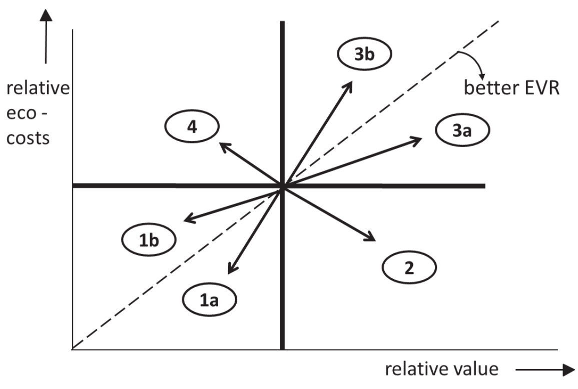


Figure 2.14

The six directions of product innovation

Fig. 2.14 depicts the possibilities of a new design in terms of its eco-costs and its value compared to the reference (the old product which is replaced by the new design). There are four quadrants:

- Quadrant 2 is the quadrant of eco-efficient value creation: it is the quadrant which fulfils the requirement of the double objective. It is the desired quadrant for 'Design for Sustainability'.

[9] We call this the EVR Decision Matrix. In Appendix V it is shown how it is applied as a design tool.

- Quadrant 1 is the classical eco-design, where often the eco-costs have been reduced at the cost of quality. In sector 1a there is a reduction of the EVR, however, the value is decreased as well, so the product is not liked (and may be hard to sell). Products in this sector harm the image of sustainable products ("products with a poor quality")[10], so this sector should be avoided. In sector 1b the EVR even increases, so even with lower eco-costs, the product is not good for sustainability at all.
- Quadrant 3 has a sector 3a which is has a lower EVR, so is good for sustainability in the case that the new product replaces the old product, causing a shift to the left in Fig. 2.7. An example is given on the packaging cases of Section 3. Sector 3a, however, may give unsustainable results when extra customers are attracted to the new product which is dirty as such, e.g. by Product Service Systems. Examples are given in Section 6.2 (car sharing) and 6.3 (boat rental). Sector 3a is therefore a grey area, where analyses must be done with great care.
  A design in sector 3b has a higher EVR, so should always be abandoned.
- Quadrant 4 is highly unsustainable: de EVR is higher, with higher eco-costs and the lower value, so such a product does not make sense from a sustainability perspective (this is the quadrant of cheap junk products).

The findings, so far, at the Delft University of Technology (from 3 PhD studies and several hundreds of design assignments for students) are that there are 3 main areas where eco-efficient value creation (the double objective of quadrant 2 in Fig. 1.14) can successfully be applied in product design:

a) 'Technical System Breakthrough' (the two examples of the hybrid car and Senseo)
b) 'Adding a Service' to a product, i.e. creating a SusPSS (for instance by enhancing convenience or by deferring payments), see Section 6
c) 'Materials Based' Eco-efficient Value Creation

The Technical System Breakthrough is most appealing (delivering the same functionality by another system), however, it is hard to accomplish. The best results are generated in practice when designers think first in terms of customer value and thereafter in terms of eco-burden (and not the other way around!).

Adding Service (creating a SusPSS) is also a promising route to eco-efficient value creation. This route works in cases where a designer has a green product of which the customer value has to be increased. SusPSS as such may lead to Technical System Breakthrough. This is dealt with in Section 6.

The Materials Based approach is by far the easiest way to generate sustainable innovations in practice, and often leads to a reduction of the eco-costs by a factor 2 - 4.

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10 Especially during the period 1970 – 1990 many environmental friendly products were launched with an inferior quality, giving sustainability a negative image.

The design strategy is here to select the materials **at the beginning of the design process**[11] on the basis of the best score for the required characteristics (tangible as well as non-tangible) combined with the lowest eco-costs. Examples in this field are the use of Ashby charts [2] [3], see Fig. 2.15. Cases are given in Section 3 and 4.
The best design strategy is to try to select:

- materials from nature (wood, cork, bamboo, bio-plastics, etc.)
- materials which are locally available (to avoid transport, and stimulate the local economy, especially in the developing countries)
- materials from recycling (C2C and the philosophy of urban metabolism or industrial symbiosis)

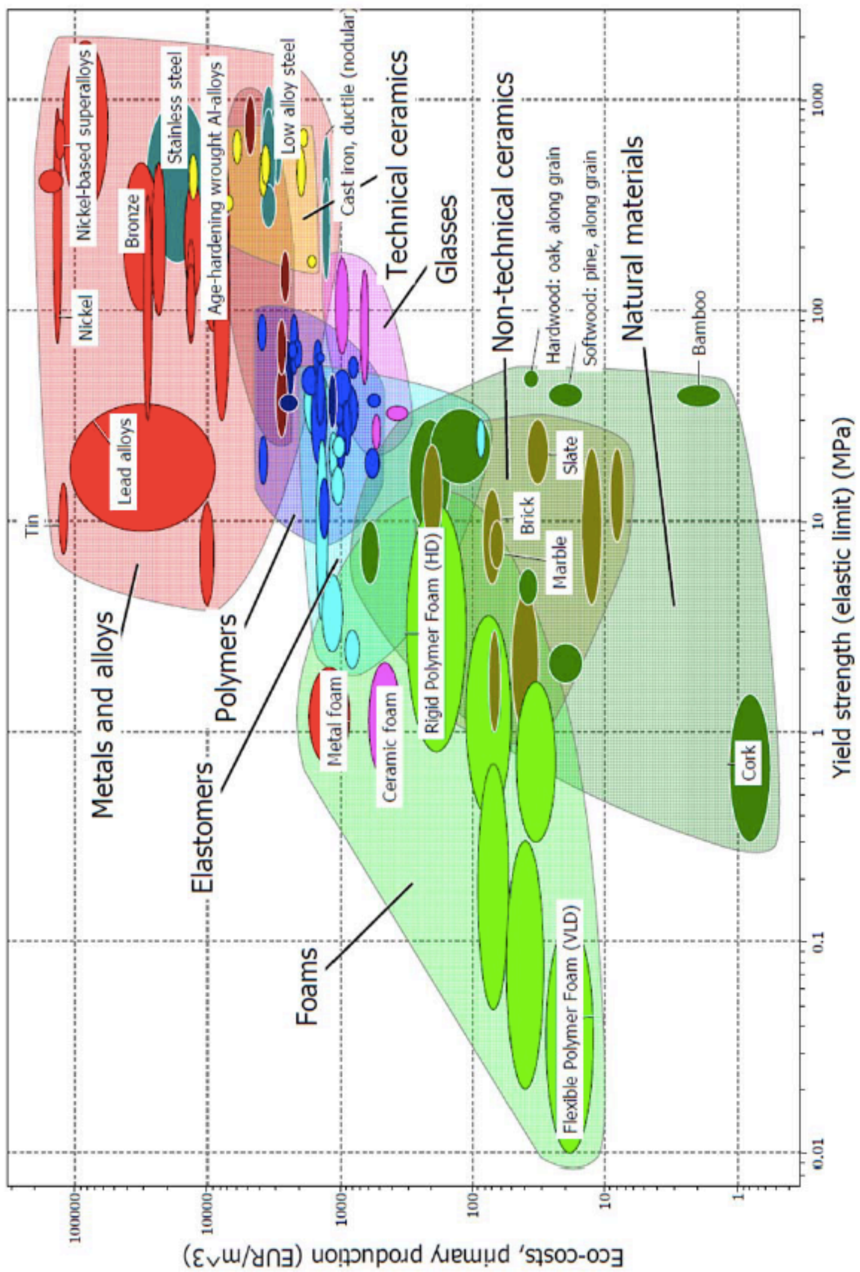
Such fundamental choices on materials can only be done at de very beginning of the design process (the 'fuzzy front end'), since the choice has impact on the whole product *system*.

There is a common misunderstanding that an innovative Materials Based approach always must lead to the introduction of totally new business models. In practice, it is not necessary to group all activities in the system circle in one organisation (a so called 'vertical integration'). Any other form of supply chain management is possible. From a technical point of view, new materials based solutions can be well organised within existing business practice.
However, from an organisational point of view there is a problem related to the introduction of such circular economy systems. The issue is the integration of the entrepreneurial activities of SMEs (the source of new developments in ICT, recycling solutions, and developments in the field of bio-based materials) with the operations of big multinational corporations (having the sales volume and the financial strength which is required for roll-out). The business models of the big companies are usually quite different from the business models of entrepreneurial SMEs. This is related to differences in business culture of SMEs and big companies. These differences in business culture make the issue of circular integration hard to tackle.

[11] Materials selection at the end of the design process is much less successful. In practice this leads to a reduction if eco-costs in the range of 10% - 30% only.

Figure 2.15

The two dimensional charts for materials selection are examples of EVR thinking: on the y-axis the eco-costs, and on the x-axis the required value of materials (cradle-to-gate)



3 Case: Innovation in Packaging of food products[12]

3.1 Abstract

The classical sustainability perspective on packaging is to reduce the environmental impact or eco-burden of the packaging, using life cycle assessment to evaluate different design alternatives. Simultaneously, the classical marketing perspective on packaging is to generate value through differentiation, for instance through providing additional convenience. These two perspectives often conflict. In business reality, there is currently no established methodology to deal with these conflicts. Life cycle assessment is methodologically incapable of incorporating the difference in convenience. This paper uses the Eco-costs/Value Ratio, or EVR, as a methodology for dealing with the environmental assessment of packaging design alternatives with such unequal 'soft' functionality.
The paper reviews the current debate on packaging and sustainability, highlighting some of the shortcomings of currently applied methodologies. It then introduces the Eco-costs/Value Ratio model, and applies it to five examples. These examples consist of pairs of products, where the product, the amount, the brand and the retail outlet are identical, and only the packaging design and the value differ. The examples illustrate how the Eco-costs/Value Ratio model fits better to design decision making in business reality than classical LCA.

3.2 Packaging in the food industry

3.2.1 Methods

To clarify what the EVR model can contribute to assessing the sustainability profile of packaging, and especially what it can mean for packaging with higher functionality than minimum requirements, we have sought examples for several case studies.

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[12] This section is a verbatim copy of the Sections 3 and 4 of the following paper (open access):
Renee Wever, Joost Vogtländer (2013) Eco-Efficient Value Creation; an Alternative Perspective on Packaging and Sustainability; Packaging Technology and Science, Volume 26, Issue 4, Pages 187–248, DOI: 10.1002/pts.1978.
For the calculations of the eco-costs, see the Tables in the paper.

Although one of the strengths of the EVR model is that it is capable of comparing designs of unequal functionality, *e.g.* portion packs with family packs, we have placed some restrictions on the selection of packages, because of the context and the clarity of this paper. In order to say something specifically about both the ecocost and the value of the *packaging* on it own, so separate of the contained product or other variables, we wanted the packaging to be the only variable that could explain the difference in value. This meant that we had to find example packages where the *same* product, from the *same* brand, in the *same* amount, was sold in the *same* retail outlet, at the *same* time. Hence the only two variables for each pair of packages would be the packaging design and the retail price.

For this article we worked with existing examples available in the market. See Fig 3.1. When applying the EVR model in a packaging design process, different design concepts would be compared with each other, or with an existing packaging solution. Five pairs fitting the selection criteria were purchased. Each pair was purchased only

Figure 3.1

The five pairs of food packaging under study

once (although never at a discount), which means the price difference reported here is based on a single store at a single time, and the weights of the packages are also based on measurements of a single sample. This means that the results, as reported in this paper, have some uncertainty as to the accuracy for the specific cases reported here. This is not a problem, as these uncertainties are assessed to be smaller than those in the eco-burden data in generic LCA databases. Furthermore, the purpose of this paper is not to study these specific examples, but to explore the potential of the EVR model for these types of packaging design choices.

The first pair of packages is for ketchup (see Fig. 3.1). Here we have an iconic glass bottle and a squeezable plastic bottle. The bottles both contain 300ml and were both bought at a supermarket in Delft, The Netherlands. The glass bottle (197.1 g glass with a 3.19 g steel cap) retailed at €1.22. This bottle represents the classic image of this brand, but at the same time the bottle is hard to fully empty, it is heavy and breakable. The alternative packaging is a combination of a PET bottle (22.69 g) with a injection-moulded PP cap (3.88 g). The plastic bottle cost €1.35 (retail price).

The second pair of packages is for bottled water (see Fig. 3.1). The difference here is that one has a regular cap, while the other has a so-called sports cap, providing additional ease of use to the user. The bottles both contain 500ml and were both bought at a supermarket in Delft, The Netherlands. The basic bottle (15.33 g PET) had a 2.03 g cap (injection-moulded PP), while the sports cap weighed 4.1 g (also injection-moulded PP). The basic bottle retailed at €0.36, while the bottle with a sportscap cost €0.61.

The third pair of packages are for mustard (see Fig. 3.1). These jars contain 215 grams and were both bought in a hypermarket near Lille, France. The jar on the right is the basic one. It is a glass jar weighing 145.1 g. It has a steel lid weighing 5,93 g. The retail price of the basic jar was €1.47. The jar on the left is a luxery 'table' jar, with a blue coloured foot (202.9 g of glass). It has a plastic lid (4.72 g injection moulded PE), which means that there is no thread on the glass, making it more presentable on a table. The paper label on both jars are assumed to be insignificant, and therefore ignored. The retail price of the luxery jar was €1.77.

The fouth pair of packages are for Italian herbs (see Fig. 3.1). These herbs were both bought at a supermarket in Delft, The Netherlands. Both packages contain 12 grams of herbs. On the left is a glass jar (85.9 g) with a plastic lid (6.49 g injection-moulded PP). The retail price of the jar was €1.39. The alternative package is a reclosable flexible plastic pouch (3.11 g LDPE), which could either be used as a refill, or a primary pack. The retail price of the pouch was €1.25.

The fifth and final pair of packages is for chocolate drink (see Fig. 3.1). Here we compare a so-called Tetra Brick (1 litre) with a multipack of 4 cans (4x 250 ml). Like with the other pairs, the total amount of chocolate drink is identical for both options. The products were both bought at a supermarket in Delft, The Netherlands. The Tetra Brik is made of a carton with a PE liner (29.94 g) and some plastic and aluminium foil for the closure (3.56 g PP and 0.069 g aluminium). It retails at €1.17. The alternative is 4 cans (each 11.69 g of aluminum) in a paper and foil multipack (3.99 g of carton and 1.82 g of LDPE). The multipack cost €3.10.

Each of these pairs can be seen as two design options, where one is more basic while the other provides users with more convenience, and therefore more value. Classical sustainability assessments (*e.g.* LCA) would continuously point to the basic designs as the better solution, in in line with the aforementioned brown paper bag dogma. The EVR model, on the other hand, will give a more balanced picture, by assessing which of the categories mentioned in Fig. 2.14 they follow.

In the analysis, the basic version will be treated as the reference (*i.e.* the existing design) and the more luxurious or more convenient version will be treated as the proposed innovation.

3.2.2 Calculations

The analyses (LCA) of the 5 pairs of product packaging have been done in terms of two single indicators: kg CO_2 equivalent (greenhouse gasses) and in terms of eco-costs (damage-based). The LCIs which are used in the analyses are from the Idemat 2010 database of the Delft University of Technology. The Idemat database has primarily been built on LCIs of the Ecoinvent V2.2 database of the Swiss Centre for Life Cycle Inventories, with extensions based on data of several other databases, like Cambridge Engineering Selector and the Danish food database. Look-up tables can be found on www.ecocostsvalue.com tab 'data', calculated by means of Simapro software version 7.3.2.

The analyses have been made for two cases: the packaging is not recycled at all, or 'upcycled' in a so-called 'closed loop' system in which the material is re-used for the same purpose. (Note that the flexible plastic herb pouch and the Tetra Brik can only be 'downcycled' in 'open loop' systems). For all packages there are also other end-of-life scenarios, such as open-loop recycling or incineration with energy recovery. The EVR model is capable of dealing with those scenarios, but they would needlessly add much complexity to the analysis, and are therefore deemed beyond the scope of this paper.

Best practice recycling rates have been taken. Since recycling rates differ for each country, the reader might interpolate for his or her own country.

The data on basic materials are cradle-to-gate of the materials warehouse (for glass incl. production of the bottle; for plastics the moulding or extrusion process have been added). The tables are kept as short as possible: items and processes which have a minor contribution to the total eco-burden are left out (the cut-off criterion is 5%, i.e. the total influence of what is left out it is expected to be less than 5%).

Transport distances are based on the average situation in the western part of Europe. The distances are given in the tables, so the reader might adapt it to the situation in a typical country or region.

Note that it has been assumed in these examples that the alternative packaging designs have no influence on the amount of content that would be wasted. Food often has a much higher environmental burden than its packaging. Especially in the case of two very distinct solutions (e.g. with the chocolate drink), the amount of wasted product might differ. In such cases the EVR method would be capable of incorporating those differences, as long as data is available, or realistic estimates can be made. However, for the purposes of this article is sensible to assume that the design alternatives do not differ on food waste.

The tomato ketchup.
The LCA summary of the tomato ketchup is given in Table 1 of the original paper. The results are depicted in Fig. 3.2.

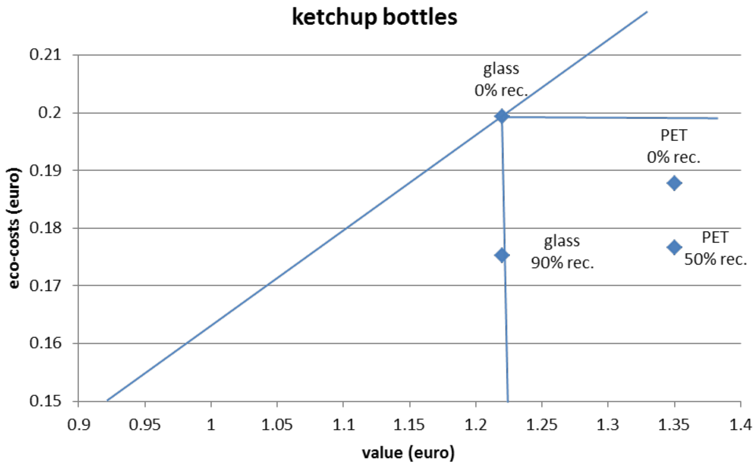


Figure 3.2

The value and the eco-costs of 300 ml tomato-ketchup in a glass or PET bottle

Fig. 3.2 shows that the redesign of the glass bottle is an example of eco-efficient value creation, (for systems with no recycling) ref. Fig. 2.14:

- the eco-costs of the PET bottle system is lower than the glass bottle system, mainly because of the low weight of the PET bottle
- the value of the PET bottle is higher, partly because the PET bottle is squeezable, which is convenient in cases of high viscosity products.

It is not a surprise that the systems with closed loop recycling score better. It is interesting to mention here that the situation is different in each country. For Instance: the glass system scores better in the Netherlands, since the Netherlands has a very good closed loop recycling system for glass, combined with no closed loop recycling system for PET.

The water bottles.
The LCA summary of the water bottles is given in Table 2 of the original paper. The results are depicted in Fig. 3.3.

Figure 3.3

The value and the eco-costs of 50 cc water, standard or with sports cap

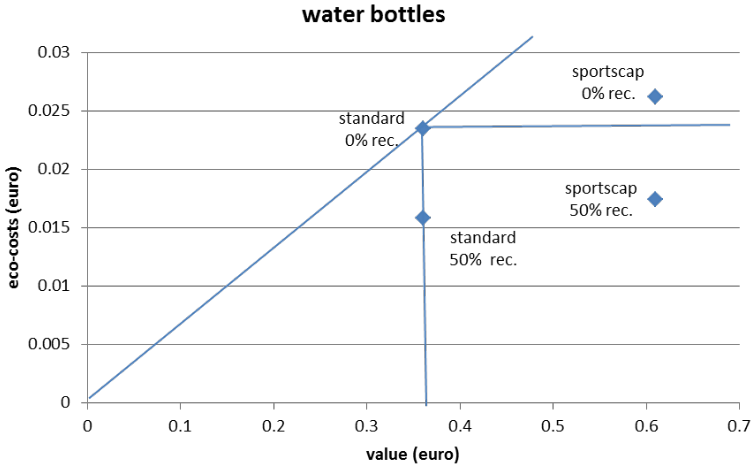


Fig. 3.3 shows that the redesign of the cap is not an example of eco-efficient value creation, since the added value of a sports cap requires added materials, and therefore added eco-costs. It is what it is expected in packaging innovations: the eco-costs is higher, however, the EVR is lower because of the added value. Hence, the sports cap is a clear example of scenario 3a in Fig. 2.14

As expected, closed loop recycling of the PET bottle system brings the innovation in the quadrant of the eco-efficient value creation (ref. Fig. 2.14).

The mustard.

The LCA summary of the mustard packaging is given in Table 3 of the original paper. It must be mentioned that the LCI of mustard is not known. A "surrogate LCI" (= a LCI of a similar product) has been applied: the LCI of Clover seed (from the Danish food database). The eco-costs of the other ingredients (mainly water, some oil and some vinegar) have been neglected. The results are depicted in Fig. 3.4.

Figure 3.4

The value and the eco-costs of 215 grams mustard jar, standard and 'deluxe'

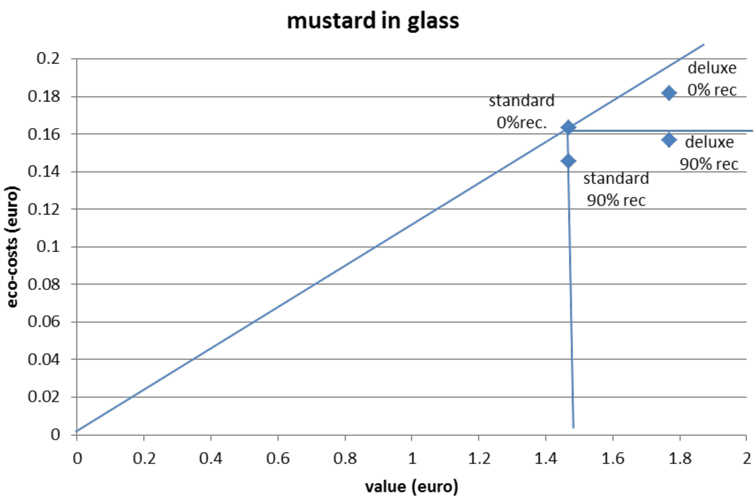


Fig. 3.4 shows that the redesign of jar in a deluxe jar is not an example of eco-efficient value creation. The added value of the deluxe jar requires added glass, and therefore added eco-costs (just like the previous example of the water bottles). It is what it is expected in packaging innovations. Compared to the previous example of the water bottles, however, the improvement of the EVR is limited: the EVR of the deluxe design has a relative improvement of far less than a factor 2 which is less than we need for a sustainable society in the far future.
Note: A rough calculation on the average relative improvement of the EVR shows that we need a factor 7.25. This calculation has been based on the required reduction of CO_2 in the far future: a factor 2.5 to get the current excess of CO_2 emissions under control, a factor 2 to give everybody on the earth the same wealth as Europe has at this moment, and a factor 1.45 for increase of population. For the detailed calculation, see www.ecocostsvalue.com, tab general.

The herbs.
The LCA summary of the herbs packaging is given in Table 4 of the original paper. Since the LCI for this herbs blend is not known, the Clover seed LCI has been taken here as a proxy for the ingredients as well. Since it is Italian herbs, sold in the Netherlands, a transport distance of 2000 km (transport in the total chain) has been assumed. The results are depicted in Fig. 3.5.

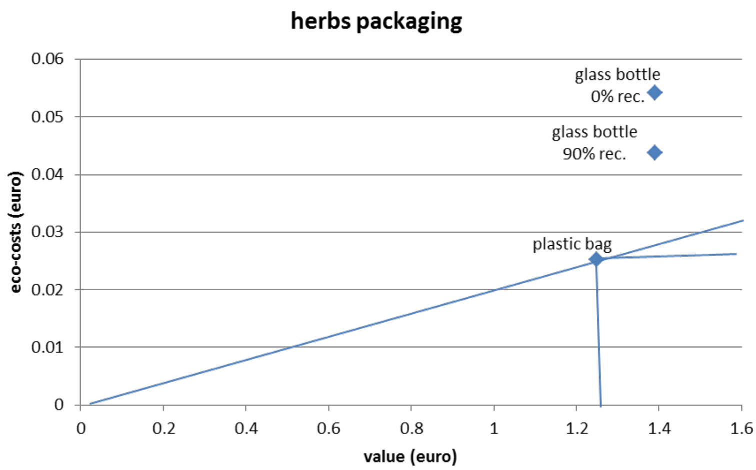


Figure 3.5

The value and the eco-costs of 12 grams herbs in a plastic bag or a glass jar

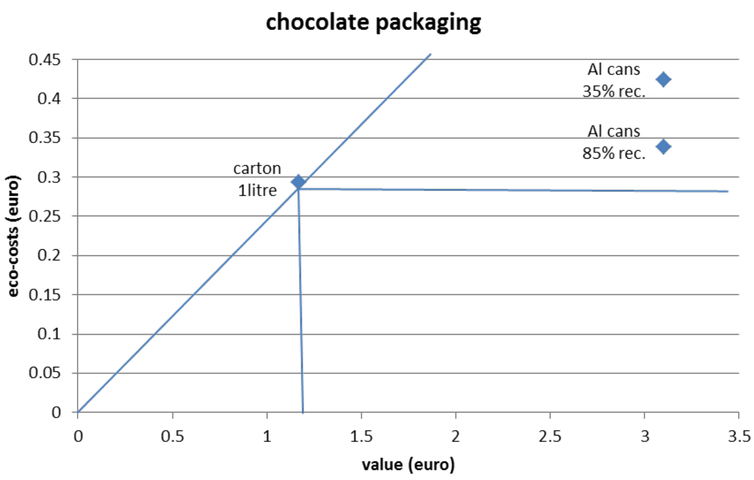
Figure 3.5 shows that the innovation of the herbs packaging is unsustainable, since the EVR of the new design is higher than the EVR of the reference product. It is striking that consumers apparently do not allocate a much higher value to the little jar (otherwise the retailer would had asked more money for it). The product can exist since the added costs are lower than the added price: from the commercial perspective it is still an attractive proposition, however, from the perspective of sustainability the product should be abandoned (reference Fig. 2.14 and 3.5).

The chocolate milk.

The LCA summary of the chocolate milk packaging is given in Table 5 of the original paper. The results are depicted in Fig. 3.6.

Figure 3.6

The value and the eco-costs of l litre water, in carton or in 4 cans



Perhaps surprisingly, the aluminium cans score rather well in terms of EVR, especially when they are recycled in closed loop. There are two reasons:

- the customer is prepared to pay a high price for the cans
- milk has a rather high eco-burden

3.2.3 Summary of calculations

The calculations have been summarized in Fig. 3.7 and 3.8.

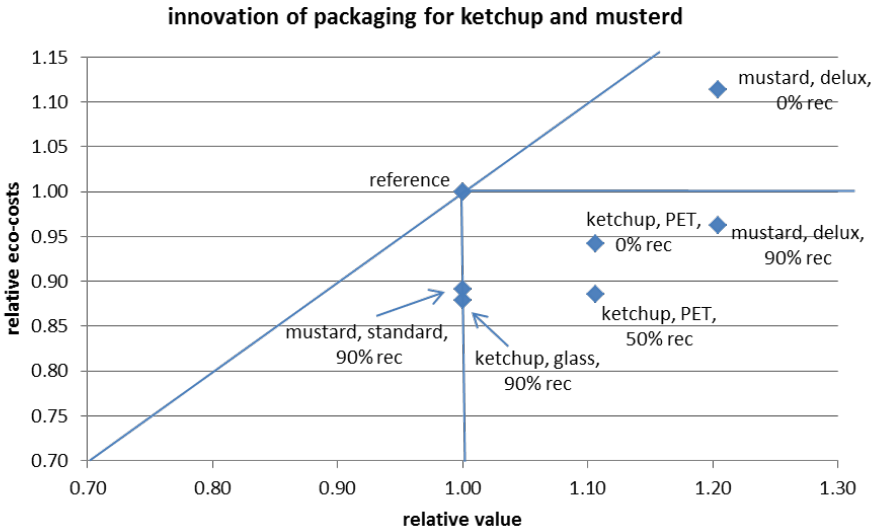


Figure 3.7

The relative eco-costs and relative value of packaging for tomato ketchup and mustard

From Fig. 3.7 it can be concluded that:

- In comparison to a basic glass package (the reference for both the mustard and the ketchup), most innovations are in the quadrant of eco-efficient value creation
- for ketchup the switch to PET can be regarded as a sustainable innovation
- In the studied context on Western-Europe, recycling is a sustainable solution (closed loop upcycling)

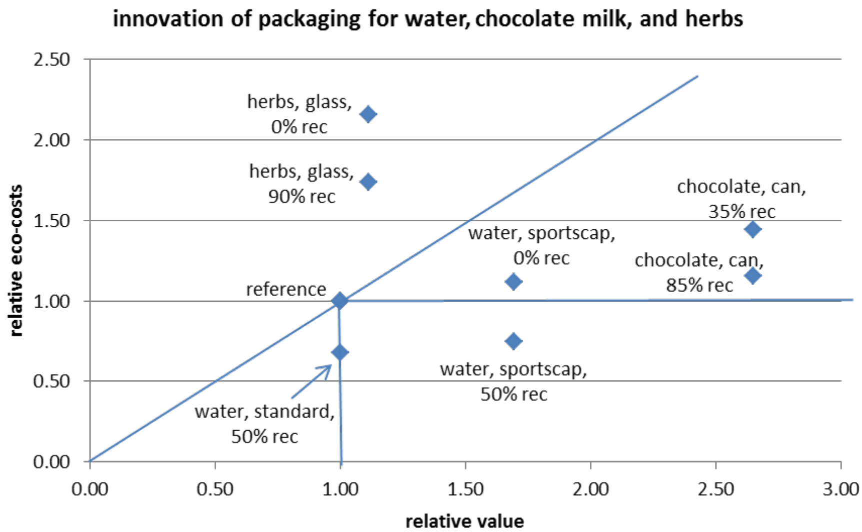


Figure 3.8

The relative eco-costs and relative value of packaging for water, chocolate milk and herbs

From Fig. 3.8 it can be concluded that:

- innovation in packaging can sometimes be economically viable, but not sustainable (herbs in bottles)
- closed loop recycled aluminium cans score well from an EVR perspective, due to the substantial increase in value.
- the extra convenience of a sports cap on a water bottle is so substantial, that the relative increase in value is considerably bigger than the relative increase in eco-burden. Hence, from an EVR perspective it is a positive innovation.

3.3 Discussion and Conclusions

The classical approach to packaging and sustainability is to reduce the eco-burden of the packaging, with the help of LCA calculations. The risk is that the reduction of eco-burden comes with a decrease in value, either through a lower physical functionality or a lower intangible functionality. Classical LCA is incapable of incorporating different values in a benchmark study. In the example of the water bottles, it would for instance be incapable of accounting for the additional convenience of the sports cap. Ignoring the additional convenience of the sports cap, *i.e.* only looking at the shared physical functionality of containing 500 ml of water, would result in an outcome of the LCA that the basic package has a lower eco-burden and is therefore more sustainable.

At the same time, the leading thought in the FMCG business is to use packaging design to create value through differentiation. The market performance of many products is based on the fact that they *do have* different functionalities, especially also intangible functionalities.

Hence, there is a friction between design for sustainability professionals and marketing professionals.

The Eco-costs/Value Ratio model applied in this paper provides a way to simultaneously consider these two business drivers. It provides a way to assess which differentiation efforts make sense from a sustainability perspective, because their relative increase in value is larger than the relative increase in eco-burden (or is even combined with a reduction in eco-burden), and which differentiation efforts do not make sense, because the relative increase in eco-burden is too big to justify the relative increase in value.

Looking at the examples described in this paper, the introduction of a squeezable plastic ketchup bottle next to, or instead of, a glass bottle makes perfect sense, because it increased value and reduced the eco-burden (see scenario 2 in Fig. 8). The sports cap water bottle, the deluxe mustard jar and the aluminium cans for chocolate drink make sense because their relative EVR score is sensible (relatively more additional value than more eco-burden, see scenario 3a in Fig. 8). Finally, the herbs jar is an example where the glass jar provides insufficient additional value to justify to additional eco-burden (scenario 3b in Fig. 8).

Note here that we have chosen to take the product with the lower value of the pair as the reference. For some this is certainly in line with the chronological order of the two design alternatives (i.e. there was first a glass ketchup bottle, and then the PET version became an alternative) for others this may be reverse.
One can also take the other package of the pair as a reference. For the ketchup this would place a glass alternative to a PET bottle in the wrong direction, namely scenario 4 in Fig. 8. Taking the sports cap bottle, the deluxe mustard jar and the aluminium cans as the reference design, would place their alternatives (basic water bottle, basic mustard jar and Tetra Brik) in scenario 1b (*e.g.* considerably less value and slightly less eco-burden), which is not an improvement. In case of the herbs, taking the glass jar as the reference point would place the plastic pouch in scenario 1a in Fig. 8, which could be considered an improvement, as it reduces the eco-burden considerably, at only a minimal loss of value, resulting in an improved EVR score.

The cases in this paper were intended as examples to illustrate the potential of an EVR approach to packaging design. The examples are not intended to give definitive answers in relation to the studied products. In an actual application in industry of the EVR method, several things will probably be different. First, the compared alternatives need not both be products that are actually on the market. Designers could take an existing solution as a reference, and subsequently score their design concepts. Also comparisons between different brands would be possible. Second, data collection would be different. Marketing would be capable of providing more robust information on the (spread of) retail prices for certain packaging solutions.
As such, the Eco-costs/Value Ratio or EVR model provides an alternative perspective to packaging design and sustainability that is better suited to business reality than the classical LCA approach.

4 Case: Design Products based on Cork[13]

4.1 Abstract

Cork, a natural, recyclable, non-toxic and renewable resource, which stems from the bark of a cork oak in the Mediterranean Cork forest (Montado), is an optimal material for Sustainable Product Design. This article describes a project, developed for the Portuguese Cork Industry, on the sustainable innovation of cork products, using the method of "design intervention" combined with the method of Eco-efficient Value Creation.

Design Intervention is a method to generate innovative products in a structured way with a team of designers, focussing on maximum customer perceived value. The method has four levels: project strategic level, concept development level, design implementation level and product diffusion level. It includes workshops, combined with work in the design studios of the individual designers. The design concepts are analysed with respect to sustainability and the market value of the prototypes are tested. Eco-efficient value creation is LCA based method with a double objective: 1. reduce the eco-burden of a product (and/or service), and at the same time, 2. enhance the customer perceived value. In this method, the combination of customer perceived value and eco-burden of the product is optimised, aiming at a high level of eco-effectiveness.

The project showed that this two dimensional approach, generated good results: 27 out of the 36 new designs ended up with better characteristics (lower eco-costs at a higher value) than their reference products. Products have been exhibited in several international cities, and are sold in design shops.

[13] This section is a verbatim copy of Sections 5, 6, and 7 of the following paper:
Ana Mestre, Joost Vogtlander (2013) Eco-efficient value creation of Cork Products: an LCA-based method for Design Intervention. J of Clean. Prod, Volume 57, Pages 101–114.
For the calculations of the eco-costs, see the Tables in the paper.

4.2 EVR of 4 cork 'mono-material' seats

The design experiment generated, among other products, 4 ´mono-material´ seats which are described in this section. The life cycle inventory data which have been used are given in Table 4.1. The value is the current price (€) in the shop in Europe.

4.2.1 Puf-Fup: Natural Cork

The "Puf-Fup" (650 x 650 x 350 mm) is an object that takes full advantage of the cork characteristics physical and sensorial characteristics. In addition to providing a comfortable seat, it offers a sensorial experience, due to the contact of the body with the soft touch of cork. The "Puf-Fup" is made of perfect natural cork spheres that provide an ergonomic and therapeutic experience with the user. The spheres are pierced and linked internally by a cotton string, allowing as many sitting and resting postures as the user can think of. Design by Ana Mestre in 2005 (Mestre et al, 2005) and further developed for Design Cork Project (Mestre, 2008) and Corque Design (CORQUE, 2009).

Table 4.1

Puf-Fup characterization for Total Eco-cost and EVR calculation

PUF-FUP Cradle to Gate: Materials & Production		Weight (kg)	Eco costs Per kg (€/Kg)	Total Eco-cost (€)
Materials	Natural cork spheres	10.20	0.039 x 2	0.79
	Cotton string	0.16	2.080	0.34
Production methods	Turning of natural cork	10.20	negligible	negligible
	Perforation (passing the string through spheres)	10.20	negligible	negligible
Database Resource: See Annex 1			TOTAL ECO-COST	1.13

Value	2650 €
EVR	0,00042

4.2.2 Lagarta Stools: Expanded Cork

Lagarta (420 x 420 x 330 mm) is an interactive, playful infinite modular seating system. You can always add another ball to the body, fitting the hollow in the curved part of the next ball. Lagarta modular seat provides a sensorial experience in a get-together scene. The Lagarta seat is made of agglomerated expanded cork, the most sustainable kind of cork composites and finished with water based varnish. Design by Ana Mestre for Corque Design (CORQUE, 2011).

	LAGARTA Cradle to Gate: Materials & Production		Weight (kg)	Eco costs Per kg (€/Kg)	Total Eco-cost (€)
	Materials	Granulate cork	5.2 (kg)	0.041 (€/kg)	0.213
	Production methods	Triturating of natural cork (electricity)	0.610 (kWh)	0.0946 (€ kWh)	0.057
		Steaming of natural cork (Using electricity)	0.610 (kWh)	0.0946 (€/kWh)	0.057
		Steaming of natural cork (Using in-house biomass)	9.610 (kWh)	0.00 (€/kWh)	0
		Turning and finishing	10.20 (kWh)	0.095 (€/kWh)	1.546
Database Resource: See Annex 1			TOTAL ECO-COST		1.87

Value	307 €
EVR	0,0058

Table 4.3

Lagarta stool characterization for Total Eco-cost and EVR calculation

4.2.3 Puf String: Rubber Cork

The concept of "Puf-String" (700 x 700 x 350 mm) is focused on the direct use of industrially available cork materials for new products without any need for complex production processes and finishing. The idea here is to make maximum use of the laminated sheets of industrial cork rolls cut in continuous strips. Thus, after a simple perforation process the puff string is mounted three dimensionally producing a seat with round shape using join screws. To stabilize the structure a belt of the same material is fasten around the circle. The final result is a seat deriving from the flexibility and possibility of being moulded, taking the rubber cork characteristics to the very limit of its elastic property. Designed by Ana Mestre for Design Cork in 2008 and implemented in 2011 by Corque design (CORQUE, 2011).

	PUF STRING Cradle to Gate: Materials & Production		Weight (kg)	Eco costs Per kg (€/Kg)	Total Eco-cost (€)
	Materials	Rubber cork	17.03	0.332	5.645
		Brassed steel	0.266	0.129	0.129
	Production methods	Laminated sheets from rolls of rubber cork, cut in continuous strips	17.03	0.0002	0.0033
		Perforated and linked	17.03	0.0001	0.0033
Database Resource: See Annex 1			TOTAL ECO-COST		5.78

Value	963 €
EVR	0,0060

Table 4.3

Puf String characterization for Total Eco-cost and EVR calculation

4.2.4 Corqui Chair: Agglomerate Cork

The “Corqui” lounge chair (600x700x690 mm) is a concept that combines comfort and attractive aesthetic lines. The cork sensorial characteristics are predominant when experience the seating on this chair or simply touching the surface. Corqui is made of high-density agglomerate cork. Corqui is a chair based on a unitary module which is replicated seven times resulting in a chair, whose pieces are glued together in sequence. An automated CNC milling machine, computerized and the glued and sanded so as to eliminate any slight unevenness machines the modules. This concept combines high aesthetic quality with an effective use of the production processes already available in the cork industry. Design by Pedro Silva Dias for SMD in 2005 / Design Cork / Corque Design.

Table 4.4

Corqui chair characterization for Total Eco-cost and EVR calculation

	**CORQUI Cradle to Gate: Materials & Production**		**Weight (kg)**	**Eco costs Per kg (€/Kg)**	**Total Ecocost (€)**
	Materials	Agglomerated cork	25.800	0.23	6.054
	Production methods	CNC Cutting of agglomerated cork blocks.	25.800	0.0002	0.002
		Gluing of finished surfaces (modules)	0.040	0.590	0.0236
Database Resource: : See Annex 1			**TOTAL ECO-COST**		6.08

Value	1450 €
EVR	0,0042

4.3 Eco-efficient value creation of 4 ‘multi-material’ products

4.3.1 Introduction

In the previous examples of the four seats, the design objective was relatively simple: “create value”. The sustainability issue was not complex: since cork is a sustainable material as such, and the eco-cost are low compared in many other materials (see Fig. 2.15).

For many other products the challenge is a bit more complex, since other materials, additional to cork, have to be applied in cases where these other materials are essential to the functionality, quality and value of the product. These additional materials often have a much higher eco-cost than cork. For such products, an analysis on the EVR is required in the design process to ensure a high value at low eco-costs (eco-efficient value creation).

In the Design Cork Intervention Project, 36 new sustainable cork products were designed for furniture, seats, technological and home appliances, tableware and apparel. Of all these products the EVR position was checked during the design process, as depicted in Fig. 4.1.

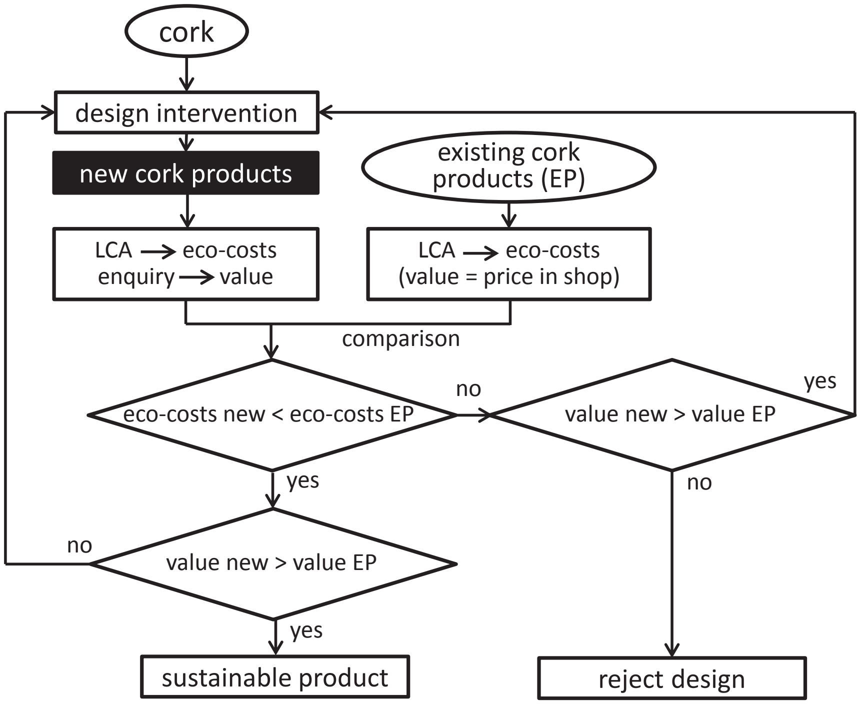


Figure 4.1

The design process of sustainable cork product

The design process of Fig. 4.1 can be summarized as follows:

1. In the first step cork was selected as a promising material for sustainable product design.
2. Then a "design intervention" was organised, where designers were asked to create products with maximum value, made from cork. The result was a group of 36 products of all kinds (chairs, baskets, tables, wine bottle chillers, et cetera).
3. After the design process, the eco-costs and the value were determined for each product and compared with an existing product. Such an existing product was selected from design shops and internet on the basis of the same function, a modern design, and the best available quality (usually the highest price). For details of such a Pareto selection, see Appendix VI.
4. Where possible, the product designs were improved in terms of eco-costs, under the condition that this didn't result in a lower value.
5. Designs with higher eco-costs than the existing product were abandoned, so the end result of the project was a list of 27 products with higher value and lower eco-costs.

Four products out of 36 new design products have been selected to explain how the analyses have been performed. The results are depicted Table 4.5 and Fig 4.2 in Section 4.4.2. The analysis description and results are further discussed below in this section.

Table 4.5

Characterization of products (original and reference) for eco-efficient value creation analysis

Product	VINE Wine Cooler	Reference Wine Cooler	CORK Thermo Flask	Reference Thermo Flask	ROLHA Candlestick	Reference Candlesticks	RINGS Bottle holder	Reference bottle holder
Image								
Material	High density agglomerate cork and metal	Thermoplastic resin	High density agglomerate cork and porcelain	Glass and Neoprene	High density agglomerate cork and aluminum	Stainless steel	Rubber Cork	Stainless steel
Dimensions	189 x 189 x 280 mm	300 x 150 x 430 mm	200x80 mm	260 mm x 90 x 90 mm	28 x 132 x 92 mm	75 x 68 mm	330 x 110 x 3 mm	200 x 100 mm
Eco-cost Design 1	2.875	1.170	0.05	0.33	0.025	0.962	0.081	0.277
Value Design 1	150 €	33 €	69 €	69 €	60 €	35 €	22 €	22 €
Eco-cost Design 2	0.353	-	0.073	-	0,05	-	0.056	-
Value Design 2	140€	-	79 €	-	60 €	-	30 €	-
Eco-cost Design 3	0.861	-	0.0382	-	-	-	-	-
Value Design 3	164 €	-	89 €	-	-	-	-	-

4.3.2 VINE wine bottle cooler

The VINE wine bottle cooler (189 x189 x 280 mm) relates to the tradition of serving wine. It´s design optimises the cork’s properties of thermal insulation, impermeability, lightness and odourlessness, making it the ideal material for keeping the wine cool. The original design of the product is composed by two different pieces: the bucket in agglomerated cork and a stainless steel base that can be easily placed on the table top, allowing saving space at the table. The stainless steel base has a regulating system that allows it to be adapted to table tops of different thicknesses and materials. The bucket can be also used alone and was projected with a diagonal cut across the top, in order to facilitate use of the bucket with the bottle inside. VINE combines elegance, functional and ergonomics, providing a new interpretation of a wine cooler. Design by Ana Mestre and team for Design Cork, 2008.

VINE is compared to a reference product with the same function. This reference product is made from a thermoplastic resin, herewith named Reference WINE COOLER and selected considering its similar design value and targeting the same niche as VINE, as well as the functionality (able to adjust to the table top). Although the lower price, is one of the best options found in the market for wine cooling.

The results of the design method are depicted in Table 4.5 and Fig 4.2. The steel plate of the original design of VINE was made from polished (shiny) stainless steel. The value was good; however, the eco-costs were too high because of the stainless steel (design 1). The first idea was to replace the stainless steel by plywood, however, that ruined the value since it looked less attractive (design 2). The best solution was a high carbon with chromium plating (design 3): the value was excellent combined with reasonably low eco-costs.

4.3.3 Cork Thermoflask

The Cork Thermoflask (200 X 80 mm diameter) is made of a combination of high-density agglomerate cork available in the Portuguese cork industry and the traditional Dutch porcelain industry from Delft. The Thermo flask is a compact "espresso coffee thermos" which can be taken to the office, cinema, outdoor sports or leisure activities. The "cork thermos flask" explores the functionality and the characteristics of two traditional materials – cork and porcelain, bringing together two ancient European technologies. Design by Tomas Schietecat and Boudewijn Van Limpt for Design Cork, 2008.

The Cork Thermoflask is compared to a reference product with the same function. This reference product is made of glass and neoprene. The reference Thermoflask is one of the top quality designs available in the market for this type of function. The use of neoprene makes it an excellence choice for isolation with very similar thermal properties compared to cork.

The results of the design method are depicted in Table 4.5 and Fig 4.2. The first design of the cork thermo flask was a combination of cork and polypropylene (design 1), the result is a good Eco-cost, however, the value is low due to polypropylene solution for the cups. A re-design was considered with a substitution of the polypropylene for a higher value option polycarbonate (design 2), however was not considered as the optimum in eco-costs and the cost increases. The last re-design had an inner porcelain container (design 3), combining low eco-cost and high value.

4.3.4 ROLHA Candlesticks

The ROLHA candlestick (28 x 132 x 92 mm) is designed like a cork stopper and fits perfectly into the neck of a wine bottle functioning as the base for the candlestick. The ROLHA candlestick is made of cork agglomerate and shaped with CNC technology. The design here present is part of a four-candlestick collection, which works individually or altogether. This product suggests a new use and functionality for recycle wine bottles. It also reinforces and symbolizes the close relationship between two traditional industries: wine and cork. Design of Fernando Brizio for Design Cork, 2008.

The selected reference product has the same function, however is made from stainless steel with the same functionality of using a bottle as base, making it the ideal product for comparison, differing in the material used and competing in the same niche-market.

The results of the design method are depicted in Table 4.5 and Fig 4.2. The first design of line Rolha candlestick (design 1) is a better choice in terms of Eco-cost value creation, with a much lower eco-cost (0.025 versus 0.962 reference product). However, cork can burn with the candles and the way to prevent this is by include Aluminium cups, as a protection of the cork (design 2). The eco-cost increases but a better value is achieved and therefore a better final solution.

4.3.5 RINGS bottle holder

RINGS bottle holder (330 x 110 x 3 mm) is a hand bottle made of rubber cork, a cork composite with a percentage of synthetic or natural rubber that makes the product flexible and elastic and easy to clean. RINGS have exceptional functional characteristics since it incorporates ergonomic qualities that make the act of serving the wine easier: it is resistant, malleable and soft to the touch. RINGS are perforated by two rings, which embraces the bottle and assist in the ritual of wine serving.

The selected reference product with the same function is a stainless steel bottle holder which has exact the same functionality and target to the same niche-market. It is considered a high quality product already well-established on the market and therefore a competitor of the RINGS cork bottle holder.

The results of the design method are depicted in Table 4.5 and Fig 4.2. Rubber cork is a special composite that can be made with natural rubber or synthetic rubber. The two situations are analysed: Design 1 (synthetic rubber) and Design 2 (natural rubber). The conclusion is that, although any of the options are a better choice compared with the reference stainless steel product, natural rubber is the best choice. A general conclusion is that cork composites should better a combination of cork with another natural resource, as shown in this case.

4.4 Conclusion

4.4.1 The for seats: EVR as a single indicator

The ranking in terms of eco-burden only, the eco-costs are (from low to high):

- Puf-Fup, eco-costs = 1.13 euro
- Lagarta, eco-costs = 1.87 euro
- Puf-string, eco-costs = 5.78 euro
- Corqui, eco-costs = 6.08 euro

These eco-costs are extremely low. But the problem is that eco-costs as such are not a good basis for benchmarking of these seats. The reason is the "functional unit" in LCA (the functional unit relates to the function of a product). For these products, the function of these seats is not only that you can sit on it, but that it is "a piece of art in the corner of your room". So the basis for benchmarking is not "eco-costs per 10.000 times you sit on it", but "eco-costs per its perceived value", where the value is a measure of the quality and beauty. The ranking is then:

- Puf-Fup, EVR = 0.00042
- Corqui, EVR = 0.0042
- Lagarta, EVR = 0.0058
- Puf-string, EVR = 0.0060

One should realise that the accuracy of LCA is not more than 30%, so Puf-string and Corqui do not differentiate in this first eco-costs ranking. In the second ranking of the EVR, Puf-string and Lagarta do not differentiate.

It must be mentioned here that these chairs score extremely low in eco-costs (a simple plastic chair has an eco-costs range of 10 – 15 euro at a price of 30 – 45 euro). The average chair in the EIPRO database has an EVR of 0.3 – 0.6 (see also the Excel product database in www.eco-costsvalue.com tab 'data').

The Puf-string and the Corqui score not very well on eco-costs for two reasons: the resin and rubber in it, and its weight. Natural cork "at the forest road" as such has extreme low eco-costs, see Fig. 2.15; hence the low eco-costs score of the Puf-fup. The Lagarta stool uses "falca" (recycle and less quality cork), however, energy is spent on the production process (trituration, steaming and tuning) and that´s why is scored in the second position for eco-cost.

Note that charts like Fig. 2.15 are extremely useful in the early design stages to facilitate materials selection. The scales are logarithmic, so the differences are rather important. Such a chart is a form of EVR diagram: the eco-costs of a material are compared to the functional quality which is required (in this case the Young's modulus). It is possible to draw a line in the chart for a specific function (like the bending stiffness of a beam). Above such a line the eco-costs to fulfil such a function is higher than below such a line. For more charts and a further explanation see [3].

4.4.2 Eco-efficient value creation of the 'multi-material' products

Four cases have been described in Section 4.2 and four cases in Section 4.3, but a total of 36 new cork products have been analysed. The total product range is presented in the original journal paper.

The customer value of each product was determined by asking the WTP of prototypes at exhibitions and in shops. Some products are already in production, and are sold in shops. For these products the customer perceived value is the sales price in the shop.

The best way to depict the design method is given in Fig. 4.2. The X-axis of Fig 4.2 is the 'relative value'='value of the new design'/'value of the existing product'. The Y-axis is 'relative eco-costs' = 'eco-costs new design'/'eco-costs existing product'.

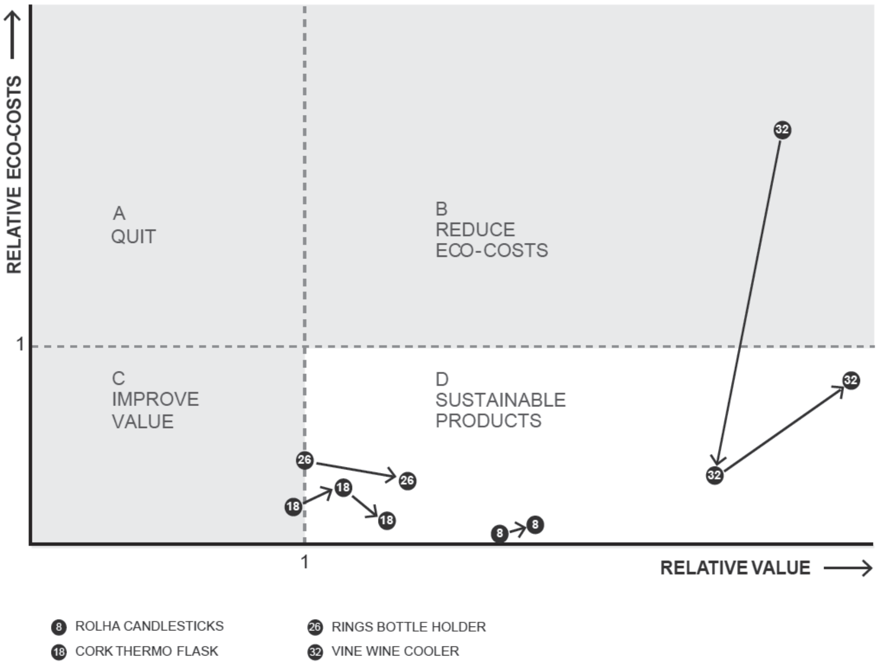


Figure 4.2

New designs and their strategic options to arrive at sustainable solutions for the 4 'multi-material' products of Section 4.3

The interpretation of the 4 quadrants in Figure 4.2 is:

- Quadrant A: 'Quit' (since the eco-costs of the new product is higher and the value is lower than the existing product)
- Quadrant B: 'reduce eco-costs'
- Quadrant C: 'improve value'
- Quadrant D: 'sustainable products'.

Therefore, the goal is to re-design the new products till the final design can be placed at Quadrant D: Low Relative Eco-cost and high Relative value.

Of the 36 final designs, 2 were abandoned (quadrant A), 5 products were in quadrant B with high eco-cost, 2 were in quadrant C with low value and 27 end up in quadrant D, as final sustainable products.

Fig. 4.3 shows the result of the project: of a total of 36 final designs, 2 were abandoned (quadrant A), 5 products were in quadrant B with high eco-cost, 2 were in quadrant C with low value and 27 end up in quadrant D, as final sustainable products.

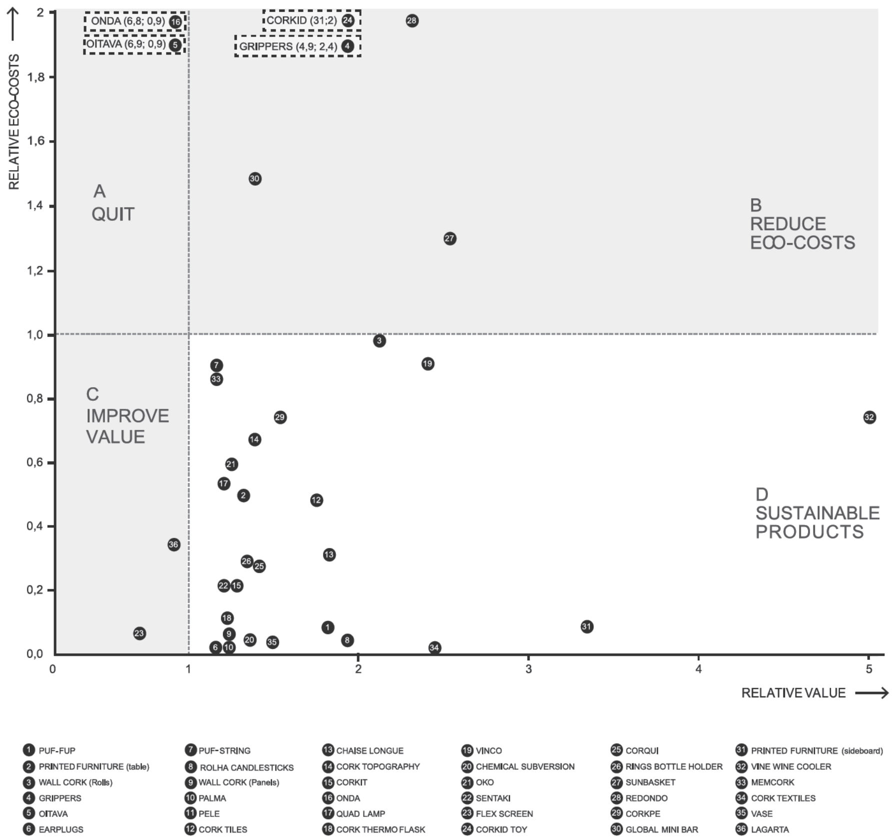


Figure 4.3

Final Eco-cost /value results of 36 cork products, including 27 final sustainable products

After Eco-efficient value creation, the 36 product prototypes have been tested in a public exhibition in Lisbon, Portugal to access the value and acceptance of the new cork products. Finally, based on public and market analysis, a selection of 15 products have been produced and commercialized under CORQUE DESIGN brand and presented in several international design exhibitions (in Milan, Helsinki, New York, Barcelona, Tokyo, Barcelona, London and Rio de Janeiro) and sold in design shops (in Lisbon, Porto, New York, Los Angeles, and Tokyo). See http://www.corquedesign.com (accessed 20-05-2013)

4.5 Discussion

The Section 4.4.1 concludes that the seat made of pure natural cork has the best result, due to the less use of energy and compounding materials. Section 4.4.2 concludes that the cork itself has a very good Eco-cost compared to many other materials as wood, metals and polymers. However, to keep a good total EVR solution, the materials that are combined with cork in the design of the new products, should be very well considered and analysed during the design process. It is therefore relevant that designers start with an open creative design approach, however, continue with a "step by step" EVR re-design method to improve the cork solutions in terms of eco-costs, and at the same time try to optimise the Customer Perceived Value.

A rather standard reaction of the project team members during the EVR assessment was the remark "that you can make every product sustainable by setting the price high". That is true, but a prerequisite for a high price is a high Customer Perceived Value, since without a high Willingness To Pay (WTP) a high price is not possible (nobody will buy the product). It is the talent of the designer that creates the value of the product.

A surprising issue for most designers is that the selection of materials really matters in terms of sustainability: Figure 2.15 shows an enormous variation in eco-costs per kilogram (note that the axis is logarithmic). The importance of materials selection on the basis on the eco-burden seems to be forgotten by many environmentalists: it is not only recycling (C2C) which is important, but also the eco-burden of primary production. Natural materials score generally well in terms of eco-costs.

It is obvious that End-of-Life is very important. Cork has favourable end-of-life characteristics as well as in the field of recycling as in the field of combustion with heat recovery (giving in LCA a "credit" for not burning fossil fuels instead). However, it was decided that it was perhaps not realistic to assume that all these products are recycled or burned with heat recovery. Such an assumption seems to be wishful thinking for the near future, since a lot of these products will end up in land-fill. For the far future, however a lot can be gained by better end-of-life solutions.

It is concluded that Cork is a great material for Sustainable Design, and has good characteristics in terms of eco-efficient value creation.
The creativity of the Designers developing value added products with cork is one of the most relevant aspects of EVR results. Such positive results, will contribute to a positive "eco-label" market position during the following implementation phase of the new cork products.

5 Customer Perceived Value and the Cost-Price-Value model

5.1 The Cost-Price-Value model, a paradigm shift

The EVR has its roots in theories of management science. In Section 2.1, the value chain of Porter (Fig. 2.2), on industry level, has already been mentioned. In the value chain model, the value is the sales price in each step of the chain[14]. Similarly, we defined the value equal to the price in Sections 2, 3 and 4.

In this section, however, we will look closer at the cost, the (sales) price and the value of a product of a company in the chain, as they are defined in modern management theories such as Total Quality Management and Continuous Improvement.

In the previous sections we looked at the price in the market as being the value (market value = sales price). The market is a specific group of potential buyers (the 'market niche'). In this section, however, we will look at the value from the point of view of a single, individual, buyer (the 'customer value').

So the reader should be aware that we will differentiate in this section between the (customer) value and the (sales) price. Understanding the difference is of crucial importance of a better understanding of the EVR model[15].

The classical management paradigm describing the function of costs, price and customer value is depicted in Figure 5.1.

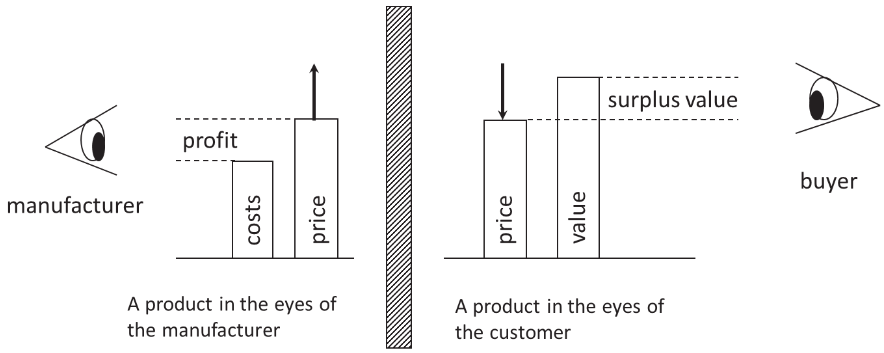


Figure 5.1

The classical paradigm is 'price driven', which leads to 'cost cutting'

[14] Note that, in a business chain, the value of the seller (the sales price) is the cost of the buyer.

[15] A common misunderstanding is that you can lower the EVR, just by asking a higher price for a product. In this section, however, it is shown that such a simple measure is not possible, unless the customer perceived value of the product will be made higher as well (otherwise the customer will not buy the product).

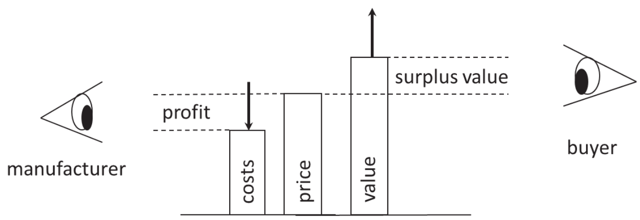
In the eyes of the producer, profit is a result of the difference between the costs of a product and its price. Managers try to reduce the costs as much as possible and get a price as high as possible.

However managers know that the buyer (the customer within the chain as well as the customer at the end of the chain) will buy the product only when, in his or her eyes, the perceived value is higher than the price (i.e. the product has a 'surplus value'). The perceived value is related to the quality of the product in the broad sense: the product quality, the service and the image.
In the classical management paradigm, the manager has no choice: when the price gets too high (i.e. the surplus value gets negative), there will be no buyers, so the only thing he can focus on is reducing costs (so called 'cost cutting'). In this paradigm, measures for environmental protection add costs, and must be kept to a minimum.

In modern management, however, the strategic focus is on the *ratio* of value and costs, as is depicted in Figure 5.2. A big difference between value and costs creates a variety of strategic options for setting the right price (creating more profit by optimisation of profit per product versus market share caused by the surplus value), see Section 5.2.

Figure 5.2

The new management paradigm is about enhancing the 'Value/Costs Ratio'



In classical management, higher value (quality) leads always to higher costs. In modern management that is not the case: there are many management techniques that lead to a better Value/Costs Ratio. Examples are: logistics (better delivery at lower stock levels), complaint management (satisfied customers with fewer claims), waste and quality management (less materials, better quality). All these examples - there are many more in the field of Total Quality Management and Continuous Improvement - lead to more value at less costs. This is called 'the double objective' for managers[16], and opens new perspectives to support eco-efficiency (it supports the first part of the eco-efficiency definition of the WBCSD, given in Section 1.1).
Note that this modern management philosophy is much more than just 'adding services' to existing products. It is about carefully improving the quality of products and

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[16] Defined in the Manufacturing 2000 program of IMD, Lausanne (1990-1996). The theories and tools, developed in Manufacturing 2000, are described by Thomas Vollmann in his book "Transformation Imperative: Achieving market dominance through radical change".
Note: Joost Vogtländer was at that time member of the advisory board.

services (as perceived by the customer) by eliminating the 'non value adding' energy, materials and work. See also Section 7.2.

The gap between the costs and the Customer Perceived Value depends on the product category, see Fig. 5.3:

- Commodities like grain, milk, and electricity have a small gap: the profit margin is small, and the sales volumes are big
- Top Quality products like sports cars, jewellery, perfumes, and diners in luxurious restaurants have a big gap: the profit margin is big, however, sales volumes are small

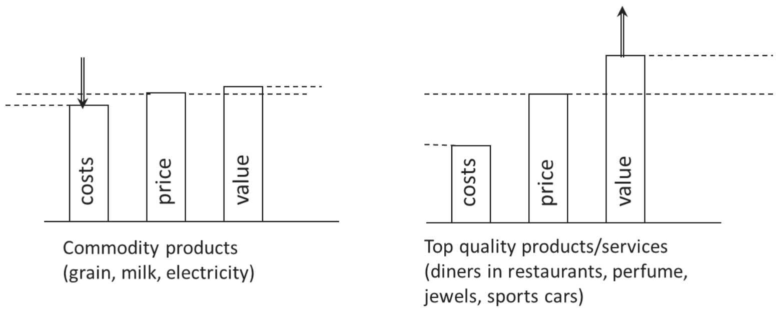

Figure 5.3

The difference of commodity products and top quality products

Another aspect of the Customer Perceived Value is the fact that it changes over time, as depicted in Fig. 5.4.

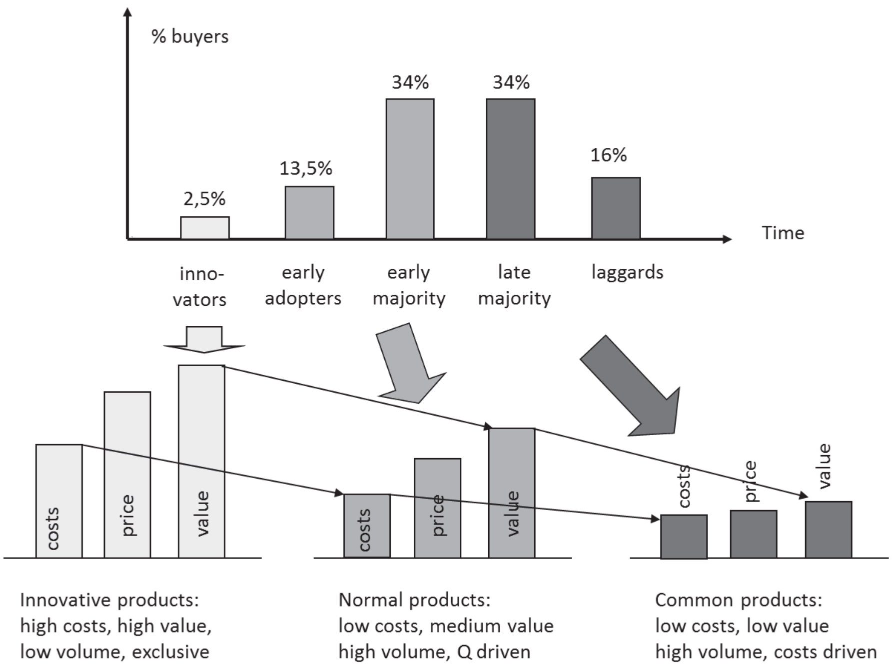

Figure 5.4

The reduction of value in relation with the theory of Rogers

Fig. 5.4 relates to the theory of Rogers on diffusion of innovation [4, Annex 8]:

- At the introduction of a product, a small percentage of 'innovators' must have the product immediately (they queue up at the first day it is in the shop; they are prepared to pay a high price, since they have fun on being the first to experience the product).
- A bit later, when the product seems OK, the 'early adopters' and the 'early majority' will follow, at a reasonable but high price level.
- The 'late majority' and the 'laggards' come in at a lower price level, at the time that the product has become a commodity.

An important aspect of the Cost-Price-Value model is related to the bundling of products and services, which is a wide spread strategy in business marketing. It is a theoretical consequence of the value chain of Porter (realising that the value chain is in reality a spider web of activities, the so called 'profit pool'). Selling services in combination with products is a profitable business practice since mankind.

Figure 5.5

The bundling of the product and the service at the introduction of mobile phones

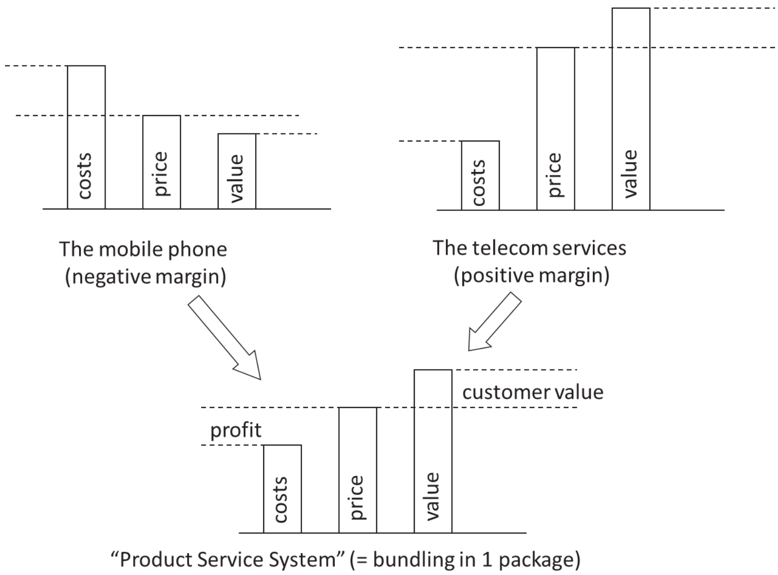

Fig. 5.5 depicts an example of the mobile phone at the introduction stage. At that time nobody was prepared to pay, say, 200 euro for a mobile phone. However, the value of being able to talk to somebody every time at every place was valued at 50 euro cents. The 50 euro cents offered a very attractive business model for telecom providers, since the costs of providing the service were below 10 euro cents. However, nobody had a mobile phone. So the trick was to sell the telecom service in a bundle with a mobile

phone, and let the customer pay per month for the mobile phone (in Section 6 it is explained that 'postponing the investment' is one of the strategies in PPS).

5.2 Customer Perceived Value and Willingness to Pay

In the previous section the Customer Perceived Value was mentioned. But what does it exactly mean?
The price that somebody is prepared to pay is called the Customer Perceived Value (in this book abbreviated by CPV). There are many definitions in literature, but most of these definitions can be summarised as "the expected fun and use (the benefits, the utility) of a product or service after the purchase". It affects the price a person is willing to pay. Note that the benefits after the purchase can be tangible and non-tangible. Note also that benefits are always the sum of positive (e.g. the fun of possessing the product) and negative benefits (e.g. expected costs of maintenance or other costs in the use phase).
The CPV is mostly applied to consumer marketing, but is applicable to B2B as well.

The CPV and the Willingness To Pay (WTP) are basically the same. But the difference in practice is that the CPV is normally applied to existing products at the moment of purchase or after the purchase in the use phase, as distinct from the WPT which is normally applied to situations where there is no direct deal (no existing product to buy). So CVP is about 'real life decisions', WTP is about 'what if'.
The consequence is that the CPV or the WTP may be different for each person, but per individual it is rather well defined. Both, CPV and WTP, can only be determined by asking people (potential buyers). For commodity products the CPV and the WTP is always near the current price in the market. For quality products, there can be a rather big difference in perception between people. One should be aware that the WTP has the disadvantage that it is not a real purchase decision, so people give often a **higher** WTP than they would spend in reality. As a consequence, the measured WTP has more spread (a higher standard deviation) than the CPV.
Enquiries on WTP are more accurate when prices are asked relative to existing solutions ("how much are you prepared to pay relative to this existing product"), or when people are asked to rank the new design relative to several existing solutions on the basis of price.

Since the CPV and the WTP are different for each person, an enquiry on the WTP does only make sense when it is restricted to a certain group of people in a 'market niche'.
A hypothetical example of a WTP measurement of 100 people is shown in Fig. 5.6. The mean WTP for the hypothetical product is 40 euro, where the range of the answers is 30 – 53 euro.

People buy the product when their WTP is more than the sales price. The measurement of Fig. 5.6 reveals that 50% of the people are expected to buy the product at a price of 40 euro. Assuming a normal distribution (Gauss curve), 84% of the people are expected to buy at 35 euro or higher, and 16% are expected to buy at 45 euro or higher. 84% corresponds to the average (mean) minus the standard deviation, 16% corresponds to the average plus the standard deviation. It depends on the costs of the product what is the optimum sales price, see Table 5.1 on the next page.

Note: In most cases in practice, the optimum sales price is not far from the average.

Figure 5.6

Example of a distribution of WTP of a hypothetical product (100 people)

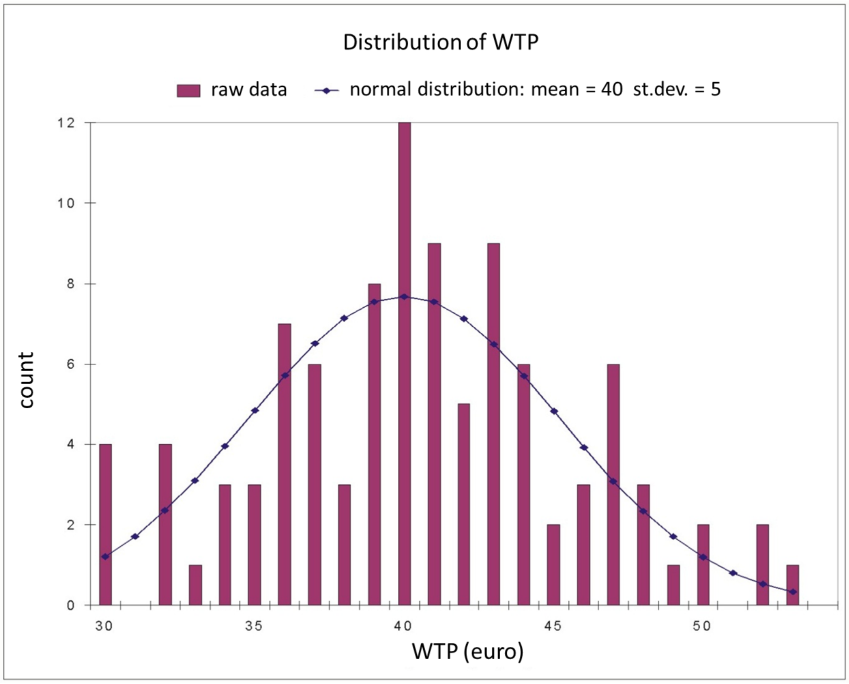

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Table 5.1

Marginal profit (euro) per 100 products, for the WTP distribution of Fig. 5.6

marginal profit (euro) per 100 products, mean WTP = 40 euro, standard deviation = 5 euro

sales price (euro)	35.00	37.50	40.00	42.50	45.00
% buyers (WTP>sales price)	84	69	50	31	16
variable costs (euro)					
25.00	840	**863**	750	543	320
27.50	630	**690**	625	465	280
30.00	420	**518**	500	388	240
32.50	210	345	**375**	310	200
35.00	0	173	**250**	233	160
37.50	-	0	125	**155**	120
40.00	-	-	0	78	**80**

5.3 Summary conclusions on the Value in the EVR model

The difference of the price and the CPV has been explained by the cost-price-value model of business science in Section 5.1. In fact, the price is a dimension of the product, relating to a group of (potential) buyers in a market niche. The CPV is related to the perception of the product by an individual buyer at the moment of purchase ("the expected fun and use after the purchase") and in the use phase thereafter (which can lead to a growing satisfaction or dissatisfaction). The WTP is related to a product which does not exist yet on the market, but has similar characteristics as the CPV (Section 5.2).
Fig. 5.7 depicts a combination of Fig. 5.2 and 5.6 to explain the combined issue.

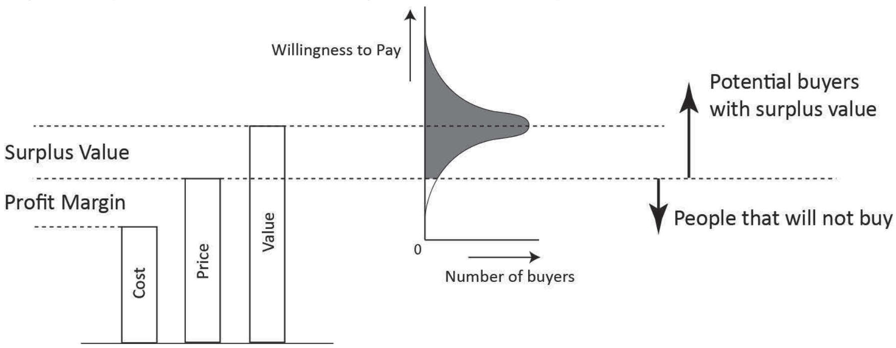

Figure 5.7

Only buyers with a surplus value will buy the product

The consequences for the meaning of the value in the EVR model can be summarized as follows:

- The **value** in the EVR model is the **market price** of an existing product, **or the average WTP** of a product which not exists yet in the market niche.

- The **market price** is a consequence of the **CPV** of the individual buyers in the market niche. The CPV is determined by the physical and functional product qualities (tangible as well as non-tangible), the service, and the image.
- As a consequence of the previous point, it is not possible to improve the EVR just by setting a higher market price, since this will affect the number of buyers: **a lower value in the EVR requires a higher CPV.** A practical example of this fact will be given in Section 6.3.3.
- The WTP and the CPV can only be determined by asking the potential buyers.
- Even for products with a rather high spread in WTP (Fig. 5.6), the optimum price setting from business point of view is quite close to the average WTP (Table 5.1); this justifies the choice in the EVR model to take the average of the WTP for the customer value.

6 Product Service Systems in the Circular Economy

6.1 Introduction to PSS: some misconceptions

The idea to bundle products and services in a Product Service System (PSS) as a way to create sustainable product solutions, has led to many discussions in the last 2 decades. There are 3 widespread misconceptions:

1. PSS is invented by environmentalists
2. PSS is per definition good for the environment
3. PSS is complex to design and implement

Ref. 1. PSS is not new, and it is definitely not something which is invented by environmentalists. It is important to realise that the idea to make a product more attractive by adding a service to it, is probably as old as mankind: it is the core of competitive strength of many SMEs as well as big companies (now and in the past):

- Aspects of providing good customer service became a major issue in Total Quality Management which evolved after World War II (first in Japan institutionalised by the Deming Award since 1950, then in USA with the Baldridge award since 1980 and finally in the EU with the EFQM award since 1985).

  One of the best advanced examples of gaining customer loyalty by extreme levels of customer services was (and still is) the service provided by the dealerships of Lexus in the USA as of its introduction in 1986. Dealerships offer cars, free of charge, to be used during maintenance and repair time, and free car washes. Some have on-site cafes and boutiques. In 2005, Lexus also began reserving parking lots at major sporting arenas, entertainment events, and shopping malls, with the only requirement for free entry being the ownership of a Lexus vehicle.
- An even older type of PSS is related to the ownership of a product: rental of products already exists for many ages. Lease is a modern form of rental (note that there is no fundamental difference between lease and rent except from financial accounting rules). Concepts of product pooling and time sharing are as old as mankind.

Ref. 2. PSS is not good for the environment as such. The misconception of many environmentalists is that you can make a 'dirty' product cleaner by adding a 'clean' service to it. The issue is, however, that the product is still as dirty as before, so what do you gain by such a combination (i.e. is the Lexus of the example above cleaner with the

service, or cleaner when you rent it)? The key to a better performance in terms of sustainability can only be the extension of the product life, or lessen the use of a product. In normal cases of rent or product pooling, PSS will lead to a **shorter** product life. The effect of lessen the use of a product (since the use is paid per hour, km, et cetera), is in most practical cases of PSS counteracted by the fact that the **PSS will attract more people to use it** (the main business reason to introduce PSS), or by the fact that the people continuously want a brand new product (a typical example of this is the case of 'pay per copy', where copy-machines are replaced much earlier than when they had been bought).
So there is neither a reason to believe that a PSS will have a direct positive effect on reducing environmental pollution, nor it will have a long term effect on dematerialisation[17].

Ref. 3. A successful PSS in business is not complex (however, scientists tend to make PSS complex by proposing systems which are not in line with the existing business structures). A good example of a successful PSS is the bundle of the mobile phone plus telecom services as shown in Fig. 5.5 (Section 5.1). It caused the big breakthrough of the mobile phone market, but the idea and implementation were rather simple. Note: The bundle of the mobile phone and the telecom service is an example of 'postponing the investment' of the customer in PSS, as described in the next section.

So we can conclude that PSS is neither new, nor good for the environment as such, nor complex.
Tukker concluded in his SusProNet study[18] that "most PSS types will result in marginal environmental improvements at best". The only exception according to Tukker is the 'functional result' PSS (i.e. the function is not fulfilled by a product, but by a service), however, such a shift in function fulfilment is not restricted to PSS (example: video conferencing will replace the need for traveling): it is already embedded in the ultimate aim of LCA based improvements, which is fulfilment of a function with a minimal use of materials.

However, from the point of view of the EVR, PSS can have a quite positive effect on sustainability (by decoupling of the economy and ecology):

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17 The guts feel that sharing a product results in less materials depletion is in most of the cases wrong, which can be seen by making the analysis cradle-to-grave instead of cradle-to-gate. When two families have a car and drive 25.000 km per year, and the life span of the car is 250.000 km, they will need two cars per 10 years, regardless whether they share the cars or not. There is also no difference between the case that both families buy a new car and use it until the end, and the case were family A buys two times a new car during the period and sells them to Family B.
There are product types in our modern society which are discarded way before they are worn out or broken, such as clothing and mobile phones. These product are, however, not suitable for shared use, so PSS is not a solution. Sustainable solutions for such products are reuse (2nd hand circuit), recycling, and change of customer behaviour.

18 Arnold Tukker, eight types of Product Service Systems: eight ways to sustainability? Experiences from SusProNet; Bus. Strat. Env. 13, 246–260 (2004)

- The environmental burden of a PSS **per euro spent** can be lower than the product without a service or with a separate service (people are prepared to pay more because of the high convenience of the combination). However, a service attached to a product which is relatively dirty, can have the negative effect of boosting the sales of that dirty product!
- The added service of a PSS can help with the **market implementation of a green product.**

Both issues require a careful design of the PSS, taking into account the relative positions in terms of eco-costs and value. In the next 2 sections this will be explained, first in theory and then in a case on SusPSS (Sustainable PSS).

6.2 A Sustainable PSS and a Non-Sustainable PSS

The effect of adding a service to a product (creating a PSS) is explained in the Sustainable Business Strategy Matrix of Fig. 6.1. Adding a service to a product, results in an arrow to the right: the service increases the value, and increases the eco-costs only with a very small amount (certainly, the eco-costs are not lowered by the extra service).

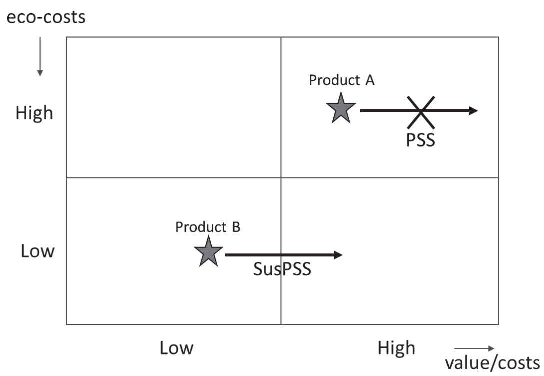

Figure 6.1

The effect of adding a service to a product. The PSS is non-sustainable. SusPSS = sustainable PSS

Product A, a relatively dirty product, stays in a PSS dirty as well. However, there is an added value because of the added service. The added value is used in business for two purposes (example: the Lexus in the previous section):

- To enhance the profit margin (the costs of the service is less than the added value)
- To sell more of the product (which is normally the business aim of the PSS)

It is obvious that the business aim of selling more ‘dirty’ products is not in line with sustainability. It is a Non-Sustainable PSS. This negative effect of sustainability has already been mentioned in Section 2, explaining the 6 directions of product innovation of Fig. 2.14.

Product B, a relatively clean product, however, suffers from a low relative value (which is often the case for green products, as explained in Section 2.2). A designer may want to make the product more attractive to the market, and may want to fulfil the 'double objective' (creating lower eco-costs as well as higher value, compared to the reference product) by adding a service. This is the case of a sustainable PSS, a SusPSS. Example: the hybrid Lexus of Section 2.4, combined with the extra service of the dealership.

An example of the importance of the relative position of a product, and the use of PSS (Fig. 6.1), is the Dutch car sharing system of Greenwheels. See Fig. 6.2.

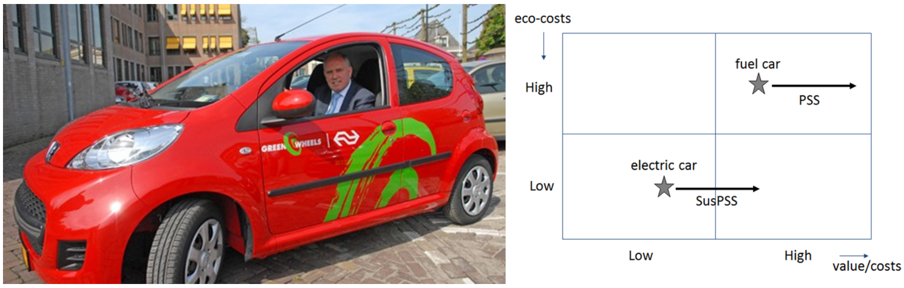

Figure 6.2

The Dutch car sharing system of GreenWheels

Basically there are two groups of users of such a system:

1. People who went by bike and train before, and want to have more convenience
2. People who had a car before, but do not want to invest in the next (second hand) car since they do not drive much

It is obvious that the transfer 'from bike to car' of the first group does not help our environment, especially not in the case of a fuel car. The second group 'who had a car before' might change their behaviour a bit, since they might drive less when they have to pay per km. However, the overall effect of the mix of the two groups is not expected to be positive for our environment[19].

The situation gets much better in the case of an electric car. The first group will pollute a bit more, however much less than in the case of the fuel car. The second group will pollute less, since they shift from fuel to electric. This is a sustainable PSS, a SusPSS.

The fact that Greenwheels offers a fuel station wagon for holiday trips, makes it even better: the added value of such an extra service outweighs the extra pollution for that period (see also Example 3, the sustainable dance floor, page 65, Fig. 6.5).

Apparently, a PSS is only a SusPSS when it is applied to products which have a low score on the relative eco-costs. The eco-costs of dirty products can only be improved by a redesign of a product, not by adding a PSS.

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[19] PhD thesis of Meijkamp, 2000, available at the repository of Delft University of Technology.
Note that the situation for carpooling is completely different from car sharing: carpooling is always good for the environment, since it results in more passenger.km per car.km. Carpooling is an example of behaviour in the use phase, rather than a PSS, since it is normally done between colleagues and friends (it is not a business as such).

There are 3 basic ways to enhance the value of green products by creating a PSS:

- Financing the product (postponing the investment)
- Adding convenience
- Adding Image or Fun (adding a 'special experience')

Example 1. Financing of the product.
The example of the reduction of the weight of part of the coach work of a car, Fig. 2.8, Section 2.4, shows that replacing a steel plate by a polymer plate can be a sustainable solution in the automotive industry. Higher costs and eco-costs of the part are compensated by lower costs and eco-costs during the use phase of such a car. For the environment it seems to be a good solution (lower total eco-costs), however, the costs of the part will more than double. A consequence of such an innovation for all parts of the car is that the car will become far too expensive: nobody is prepared to spend the extra money, even when the expenditures in the use phase are lower. The solution is that the car is sold via operational lease (including fuel).
The same situation exists in the market of electric cars: the big investment in the battery pack of the car, and the related risk that somehow the pay-back of a low price for the energy might not effectuate, results in a poor position in the market. Renault realised that leasing of the battery pack is the solution.
A third example of financing of the product is the example of the mobile phone + telecom service as shown in Fig. 5.5.

Financing of an initial investment is not only relevant in consumer markets. It has even more examples in the B2B markets (where the concept of leasing was invented to keep investments 'off balance'). Most of these PSS solutions have nothing to do with a better environmental over-all performance: many of the solutions which are claimed to be green, are not green at all (which reveals when the system is analysed properly), such as leasing of copier machines or 'print per page' systems. There are, however, a few good examples of a SusPSS.
One of the well-known SusPSS examples is the collaboration of 3 European companies in the automotive industry:

- an equipment supplier: Pero AG
- a chemical supplier: Safechem Europe GmbH
- a manufacturer of metal parts: Magna Steyer, Automobiltechnik Blau

The Austrian firm Pero AG developed a machine which cleans metal parts in the automotive industry, with the advantage of recycling the cleansing solvent (a so called concept of 'take back chemicals'). Since it was not logical for Magna Steyer to invest in such equipment, the system was sold as a 'clean per part' system by the solvent supplier Safechem Europe GmbH. It is an example of the design of a green system, combined with 'off balance' financing for the user.

Example 2. Adding Convenience.
An example of a PSS which gives convenience is the Dutch "OV-fiets" a combination of train + bike. It is a convenient bike rental system, designed to bridge the distance between the train station and the office in the city. See Fig. 6.3.

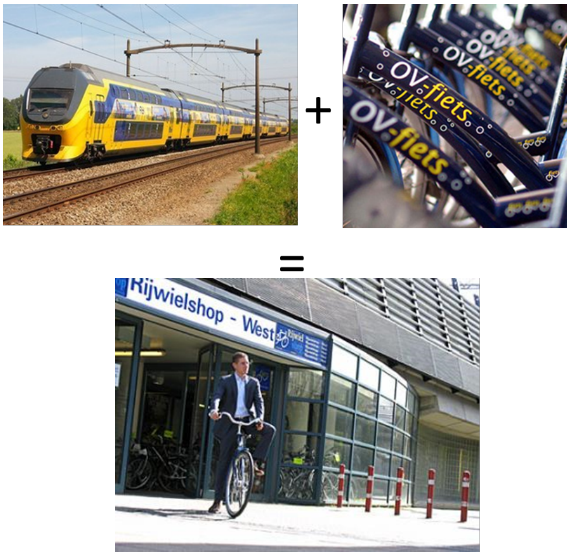


Figure 6.3

The 'OV-fiets', a Dutch PSS which is designed for enhanced convenience of commuting by train

Another example of convenience is the take-back system of Nespresso coffee cups: the empty Aluminium cups can be returned in a bag by giving the bag to the parcel service man who delivers the new coffee cups ('reverse logistics').

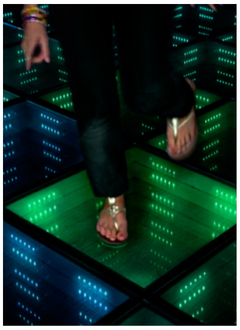
Example 3. Adding Image or Fun (adding a 'special experience').
The introduction of the Toyota Prius in the US is a rather brilliant example of adding Image by means of a PSS. Toyota made some mistakes in the introduction in Europe, ending up with a rather dull image at the start. They learned from it, and did it totally different in the US. The first step was that they offered the car to Hollywood stars, adding the service of personal painting. See Fig. 6.4. Celebrities could ask for their own

Figure 6.4

Actress Kate Bosworth shows that she is proud on her Prius and her new style of living

special paintings on their car: not only one colour, but a real painting design with a lot of colours. The result was that some celebrities did it to draw attention, and then it became cool to drive such a car. Then Toyota sold cars to other celebrities, who wanted to join the hype but didn't like the wild designs: they bought a Prius in one colour. That was the moment that Toyota introduced the Prius to the public, claiming that you can "drive in the same car as Brad Pitt".
For an advertisement, see http://www.youtube.com/watch?v=QnSs0UF6Rbk (accessed at 20-05-2013)

Another example of another type of adding image or fun ('special experience') is a PSS called 'the sustainable dance club', with 'the sustainable dance floor'. See Fig. 6.5.The sustainable dance floor is a transparent dance floor which can convert the movement of the dancers in electric energy, which amount was shown at a big sign on the wall. The concept was advertised as: "…doing your part for the environment doesn't have to be boring and you don't have to stop doing the things you love…".
See also http://www.youtube.com/watch?v=xoewlHwI3U4 (accessed at 20-05-2013)



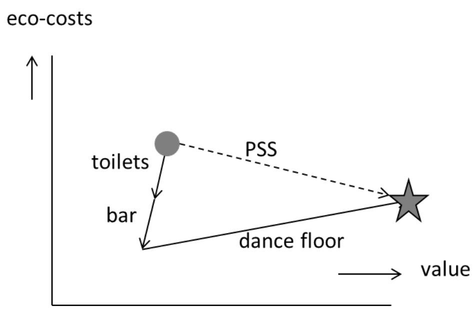


Figure 6.5

The concept of the sustainable dance floor only works as a bundle of products

The issue here is that the dance floor as such hardly generates enough energy to compensate for the energy which is required to make the dance floor system, so the LCA of the total system shows no eco-benefit. However, it is really fun, so it adds much value. Fig. 6.5 shows that it only works in a bundle of products: a water free toilet (gain in eco-costs, but degradation of value), a zero waste bar (minimizing eco-costs, however, at the cost of some value). The bundle of these products results in the right direction of the innovation: the double objective of less eco-costs with more value.

Concluding.
When a product is dirty as such, PSS does not help to make the product cleaner. On the contrary: a PSS is unwanted in that situation, since it attracts extra buyers. The only right thing to do with a dirty product is to redesign it, and improve its sustainability by reducing materials, energy and transport. For a full checklist see Appendix IV.

When a product is green, and has a poor relative value, then the designer has to add quality and/or the company has to add a PSS (by upfront financing, adding convenience, enhancing image). See Fig. 6.6.

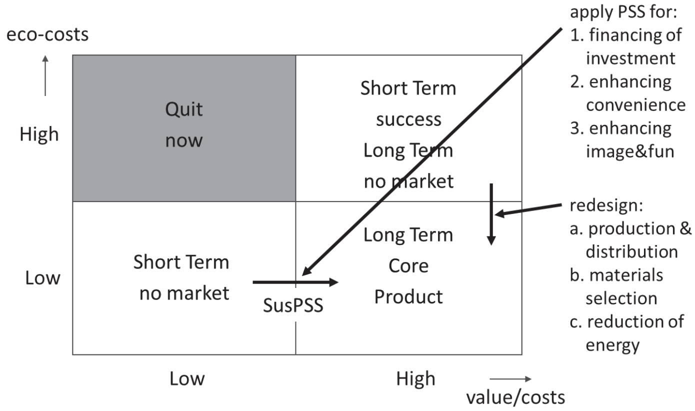


Figure 6.6

Sustainable Enhancement Strategies of the EVR of a Product Service System

6.3 Case: sustainable water tourism in the Netherlands [20]

6.3.1 The aim: more tourists with less regional pollution

An interesting case of creating a sustainable business model in the circular economy is the case of sustainable water tourism in a lake district in the northern part of the Netherlands (the area of the 'Friese Meren' in the Province of Friesland). See Fig. 6.7.

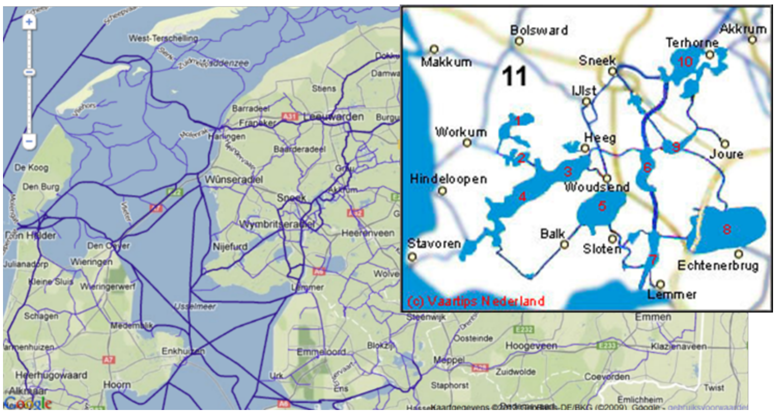


Figure 6.7

The province of Friesland and the Frisian Lake District.

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[20] Sections 6.3.1, 6.3.2 and 6.3.3 are almost verbatim copies of Section 3.1, 3.2 and 3.3 in: Scheepens A.E, Vogtlander J.G, Brezet J.C; Two LCA based models to analyse complex (regional) circular economy systems. Case: making water tourism more sustainable; Journal of Cleaner Production, 2014, submitted. See the original paper for details, references, tables (on eco-costs, carbon footprint, and ReCiPe points), and the application of the Circular Transition Framework to describe the transformation activities.

This area has had a stable number of tourists for the last decennium: approximately 1.2 million overnight stays in marinas per year), however, in recent years water recreants and their individual expenditures are in decline. The question is what can be done to expand the regional tourist industry, and at the same time reduce the regional pollution of the lakes, reed lands, and surrounding canals.

In a sense, this is the double design objective of Section 2.5 at a regional scale:

- higher value of the existing product service systems (e.g. rental of family boats in combination with the 'experience' of the regional nature and the regional hospitality industry)
- less regional pollution caused by these tourists

To achieve this double objective, the Province of Friesland has started the following projects:

- the development and introduction of a 'water navigation system', which is an internet information system on waterways, lakes, reed lands, and other natural areas of interest, social activities in villages, and advertisements of local shops, restaurants, museums
- restriction of access to wet areas where nature has to be protected (electric boats are allowed, diesel and petrol boats are forbidden)
- subsidies for the introduction of a vast grid of charging points for electric vessels in marinas and beyond
- subsidies for conversion of diesel propulsion systems of rental vessels to (hybrid-) electric propulsion systems

The Delft University of Technology is involved in these projects. Here it was realized that changing the propulsion system from diesel to electric is the first important step, but a lot can be gained as well by a total sustainable redesign of the vessels itself.

In the next sections, the design options for product service combinations are analysed in terms of the required double objective of eco-efficient value creation. It will be explained that the water recreation system is a normal (non-sustainable) PSS, whereas electric vessels can only be introduced in combination with the restricted areas. The combination will result in a viable business model (SusPSS) for the family-boat rental companies.

6.3.2 The Water Navigation System: added service to delight tourists

The basic idea of the Water Navigation System is that many tourists are relatively strangers in the region. As they are travelling around they need actual information on the area where they are:

- water depth, opening times of bridges, information on marina's

- natural areas (with descriptions of the wildlife and pictures of the landscapes)
- practical information on villages, like restaurants, bars, shops (with opening times)
- places to visit like museums with opening times and other information
- local concerts, festivals, fairs, town markets.

With the aid of such an information system, tourists can instantly plan their activities, better suited to their needs and personal interests. When tourists have a good experience during the holiday, and they are delighted, there is a high chance that they will come back and tell it at home to other people, which will result in more tourists in the region.
As such, the extra activities of one tourist of such an added service do not generate a lot of extra eco-burden, compared to the eco-burden of the boat and the diesel used during one week holyday, as shown in Fig. 6.8.

Figure 6.8

The value and the eco-costs of one week boat rental in Friesland Lake District

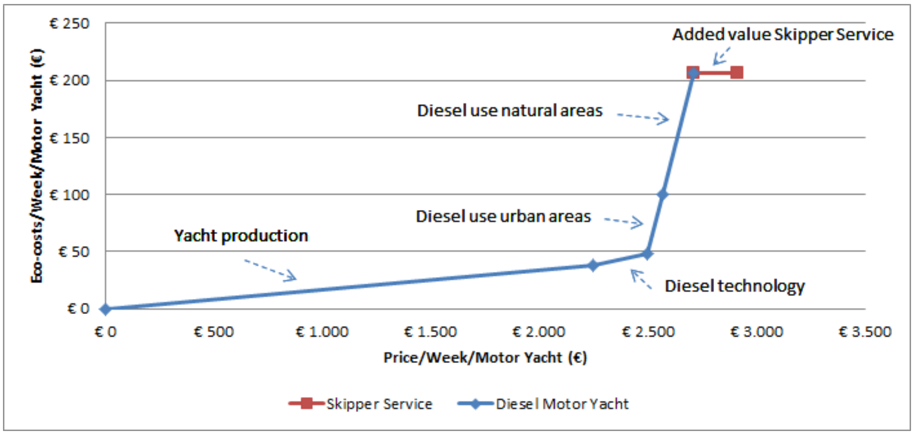


Fig. 6.8 shows that the eco-costs of the yacht are relatively small in comparison to the eco-costs of the diesel. The eco-costs of the water navigation application itself is negligible, as well as the direct value (the price), since modern people expect that internet applications are complimentary.
The interesting issue about such an application is, however, that the indirect value of it can be rather high in terms of the value of the total bundle of the PSS: the 'experience' of a special trip through nature, a visit to a museum, or an evening in a restaurant, can make or break the holyday. The character of such a type of extra value is that it is not paid for in advance, since it is not expected at the moment of purchase of a boat holyday. It is a 'Delight Quality', as further explained in Section 7.4, and can only be measured at the end of the holyday. Delight quality enhances the 'surplus value' (the gap between price and value, see Fig. 5.2 and 5.7). It generates 'repeat customers', and that is exactly the aim of the province of Friesland.

The effect on the regional environment, however, is far from positive. The total motor yacht rental market in the region is estimated at 800 boats which are rented for approximately 19.35 weeks per year on average, resulting in 800 * 19.35 = 15,480 'boat.weeks'. The total related eco-costs is 15,480 x € 206 = € 3,188,880. Under the assumption that the water navigation application creates 20% more repeat buyers, the eco-costs in the region will be 20% more, i.e. € 637,776, of which more than 50% is estimated to be emitted in natural areas during the use phase, see Fig 6.8.

The conclusion is that this water navigation service has its economic effect, but is unsustainable on system level. The regional calculation is depicted in Fig. 6.9.

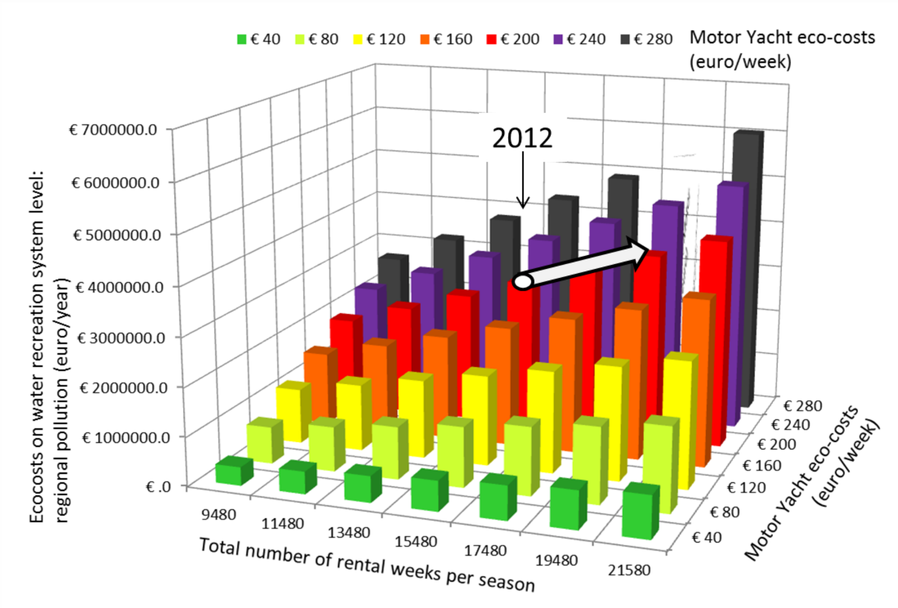


Figure 6.9

The regional effect of the water navigation system service in the Friesland Lake District

The arrow in Fig. 6.9 shows that the water navigation service causes a higher eco-burden in the region, because of the increase of tourists.

This is caused by the fact that the product (the motor yacht) is unsustainable, and remains unsustainable after the service is added, in combination with the fact that the service stimulates the use of the unsustainable product.

The only way to make this PSS sustainable is to redesign the yacht as well as its propulsion system from diesel powered to electric. The latter is extra important, because it diminishes the pollution in the natural areas.

6.3.3 From diesel powered to electric propulsion

For the standard yacht, two alternative solutions are depicted in Fig. 6.10:

- A hybrid system which is available for this type of boat, i.e. an electric motor in series with the diesel motor, with enough lead-acid batteries for 3 hours at medium speed (22 kW)

- An electric system (without diesel motor), with enough lead-acid batteries for 8 hours at medium speed (22 kW)

For the hybrid system in Fig. 8, the assumption has been made that 50% of the required energy in a week is delivered by the national power grid (UCTE electricity mix) or windmill parks, and the other 50% is delivered through diesel. For the full electric system, the assumption is made that 100% of the energy is generated at a windmill park or the national grid, charging the boats at night.

Figure 6.10

The value and the eco-costs of one week boat rental for three types of propulsion systems (55 kW max. 22 kW oper.)

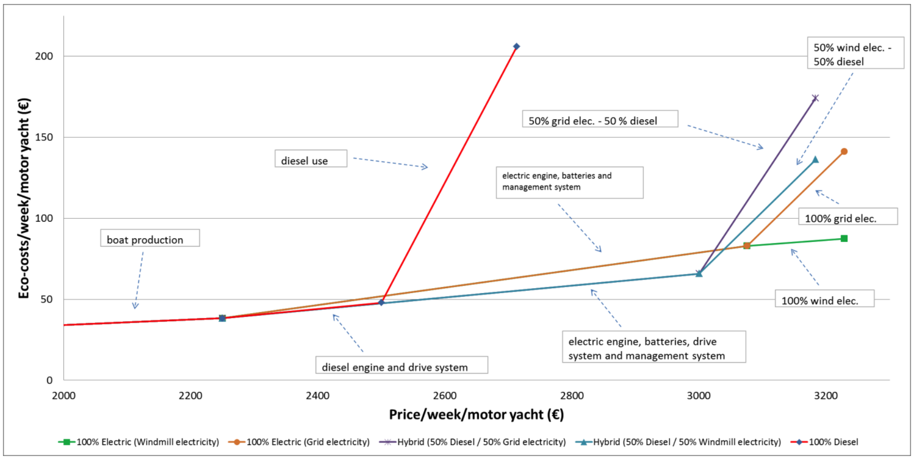


Fig. 6.10 shows that hybrid and full electric systems for boats are considerably better for the environment than diesel propulsion systems, especially when the electrical power comes from a windmill park: the eco-costs of such a yacht can be half of the eco-costs of a diesel yacht.

However, the hybrid system has one big problem in practice: nobody seems to be prepared to pay the 20% extra price. There are two hybrid rental yachts in the region, which are subsidized by the Province to reduce the price level the level of diesel yachts. At that price level the tourist is a happy repeat buyer, but at a higher price level there is the problem which is similar to the experiment described in footnote 4: the vast majority of the tourists regard sustainability as important, but is not prepared to pay more for it.
Apparently, the customer perceived value (the WTP) at the moment of purchase is lower than the value for the vast majority of tourists, see Fig. 6.11 (in contradiction how it should be, see Fig. 5.7).

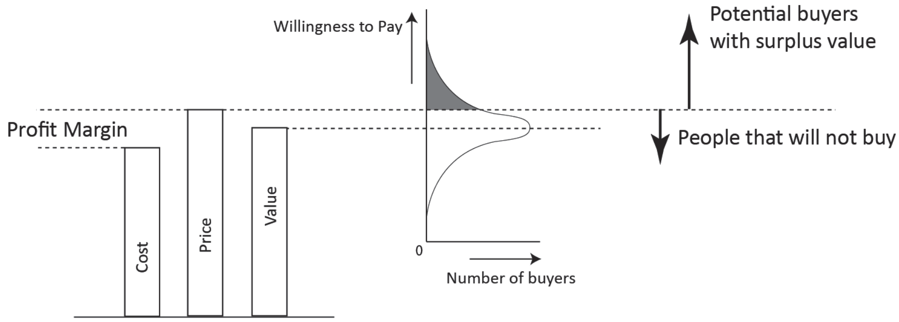


Figure 6.11

The problem of a hybrid boat:: the price is higher than the perceived value (the WTP) for the majority of buyers

The question is now what can be done to enhance the Willingness to Pay for this sustainable innovation?
The solution is shown at another little region in the Netherlands: the Nieuwkoopse Plassen. This is a lake with extensive reed lands, which are forbidden for diesel boats. There is a flourishing electric boat rental, since the tourists are willing to pay for the experience of the beautiful nature, which is only accessible by these electrical boats. The same applies to a Dutch region called 'De Biesbosch[21].
The Province of Friesland is planning to extend the protected areas as well. When they do this, it affects the competitiveness of hybrid and electric boats (in comparison with diesel boats) in the way it is depicted with the arrows in Fig. 6.12.

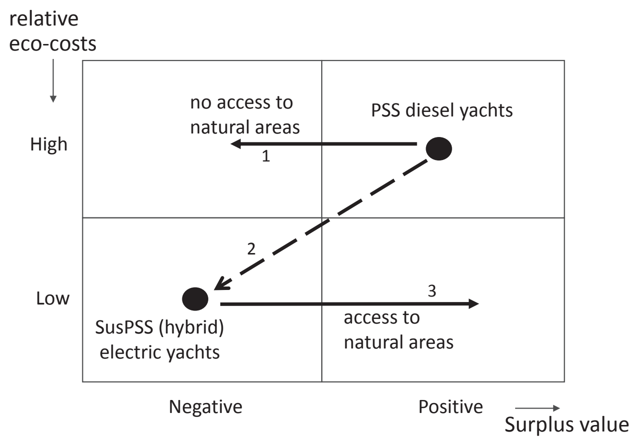


Figure 6.12

Restricted access to natural areas will decrease the surplus value of diesel boats and increase the value of hybrid and electrical boats

Arrow 1 in Fig. 6.12 represents the tentative decline in surplus value for diesel yacht rental due to restrictions on diesel yachts in natural areas. Arrow 2 depicts the expected decline in environmental impacts and surplus value associated with the introduction of

21 In other countries we see similar successful policies with regard to sustainable tourism, e.g. marine reservations in California (www.dfg.ca.gov/marine/mpa/defs.asp)

hybrid or electric yachts because of the higher price of it. Arrow 3 represents the tentative increase in surplus value for hybrid or electric yachts related to the absence of restrictions for entering natural areas in the region.

This means that the hybrid or electric boats are only feasible in the rental business, when the Province of Friesland introduces restrictions for diesel boats which can be used in the marketing of hybrid and electric boats. Note that marketing and communication is required to underline the advantage of having electric propulsion to enter protected natural areas: tourist must be made aware of it **before** they rent a yacht (this is market strategy number 3 in Fig. 7.4, Section 7.3).

Fig. 6.11 suggests that full electric is a better option that hybrid, since the price is lower. But it is important to realize that there are differences in terms of value, resulting in different markets:

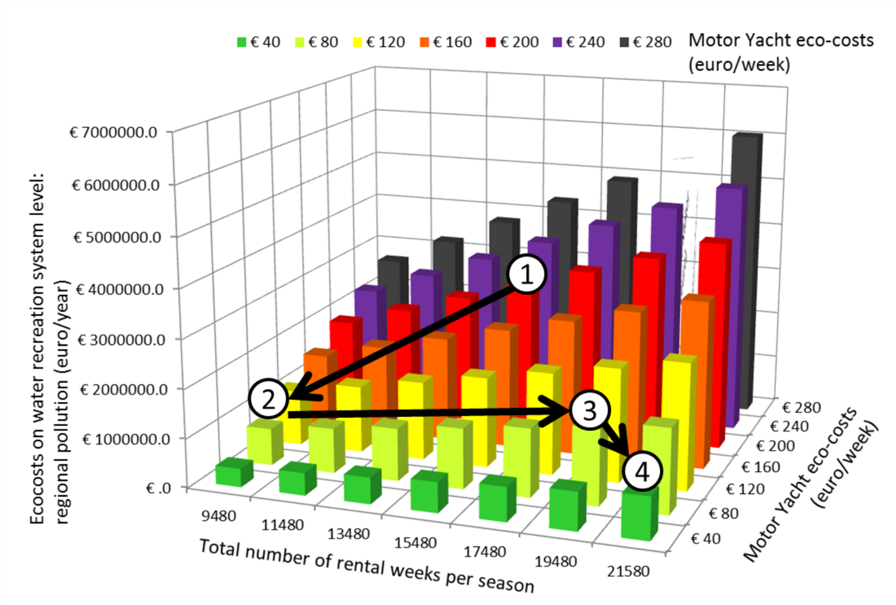
- the full electric system can only thrive when the local policy makers implement a high density grid of electric charging points in marinas in the region
- full electric systems are not suitable for people who want to go outside the region

The combined business model of water creation in Friesland fulfils the double objective of eco-efficient value creation. See Fig. 6.13. It combines:

- more tourists in the region, attracted by the protected natural areas
- less regional pollution caused by these tourists

Figure 6.13

Tentative effect of the introduction of electric or hybrid boats, in combination with protected natural areas



Point 1 in Fig. 6.13 represents the current situation: all boat rentals are diesel. Point 2 depicts a tentative decline of tourist when diesel is replaced by electric or hybrid. Point 3 depicts a tentative growing number of tourists when large protected natural areas are introduced (accompanied by the appropriate marketing and communication including the water navigation application).

Point 4 in Fig 6.13 is the ultimate goal: replacing the current steel vessels by vessels made from materials which are more sustainable, like softwood which has been made durable by non-toxic modification.

Point 4 is an excellent starting point for further development of sustainable tourism.

6.3.4 Redesigning the hull of the vessel

The ultimate goal of sustainable water tourism requires a total sustainable redesign of the vessels itself. The redesign of the shape of the boat is beyond the scope of this book; however, the aspect of the selection of materials is the most influential factor to reduce the eco-costs, referring to Sustainable Enhancement Strategies as shown in Fig. 6.6.

The typical conventional boat (steel hull) in this study has the following characteristics:
Length (overall): 10.70 m
Weight: 8000 kg
Weight hull and deck: 4200 kg, production waste: 40%, total eco-costs 4140 euro
Weight interior wood (MDF): 2500 kg, production waste: 50%, total eco-costs 568 euro

The question is whether or not it is possible to reintroduce wood as the material for the hull and the deck. New technologies can make this feasible:

- new technologies to make softwood durable (without treatment with toxic substances), like the thermal processes (Plato wood) and the process of acetylation (Accoya wood)
- new technologies to shape wood (e.g. laser techniques), to reduce the labour costs (one of the reasons of the diminishing production of wooden ships in the last decades is the high costs of labour)
- new sustainable polymers for glue applications

When the low carbon steel hull and deck are replaced by wood, the wall thickness has to be increased by a factor 3. The density of Accoya is 500 kg/m3, the density of steel is 7800 kg/m, so the weight of a hull can be reduced to 25%. The eco-costs/kg of Accoya (made from European softwood) are 23% of the eco-costs of low carbon steel sheets. This results in a reduction of the eco-costs of the hull and deck to 5 – 6 %. So the eco-costs of the total boat can be reduced to approximately 50%.

Note: the reduction of the weight of the hull with 3000 kg is quite important for the full electrical boat, since the estimated weight of the lead-acid battery pack is 5400 kg for 8 hours operation. (The extra weight of the hybrid system with 3 hours electric operation time is estimated at 2400 kg).

7 Enhancement of value: theories on Quality Improvement

7.1 The 'dimensions' of value (quality)

Eco-efficient value creation is not only about lower environmental burden, but also about higher value. So, it is important to understand (unravel) the different aspects of value in order to get to grips with the improvement of it.
In Fig. 2.1, Section 2, it is suggested that value comprises three main aspects:

- product quality
- quality of service
- image

Garvin was the first who unravelled the 'dimensions' of product quality ("Competing on the 8 dimensions of quality", Harvard Business Review 1987):

1. Performance or the primary operating characteristics of a product or service.
   Example: for a car: it is speed and acceleration; for a restaurant: it is good food.
2. Features or the secondary characteristics of a product or service.
   Example: for a restaurant: it is linen tablecloths and napkins.
3. Conformance or the match with specifications or pre-established standards.
   Example: for a part: it is whether this part is the right size; for a restaurant: it is whether the meat is cooked according to your request (e.g. "medium or rare?").
4. Durability or product life.
   Example: for a light bulb: it is how long it works before the filament burns out.
5. Reliability or the frequency with which a product or service fails.
   Example: for a car: it is how often it needs repair; for an airline: it is how often flights depart on schedule.
6. Serviceability or the speed, courtesy and competence of repair.
   Example: for a car: it is how quickly and easily it can be repaired and how long it stays repaired, for a mail order house: it is the speed and courtesy with which an overcharge is corrected.
7. Appearance/aesthetics or fits and finishes.
   Example: for a product or service: it is its look, feel, sound, taste or smell.
8. Image/perceived quality or reputation.
   Example: for a product or service: it is the positive or negative feelings people attach to any new offerings, based on their past experiences with the company.

Dimension number 8 is of another nature than dimension 1 through 7. Modern literature distinguishes between:

- product quality (dimension 1 thru 5),
- quality of service (dimension 6):
  - direct service aspects, like direct service in retail shops, after sales service, logistical service (short delivery times, in time delivery, no damage) and maintenance service
  - the service which is bundled with the product, as dealt with in Section 6
- appearance and image (dimension 7 and 8); the image of the product, the brand name and/or the company, dealt with in Section 8

7.2 A powerful concept for designers: 'wastage of quality' (and 'value engineering')

In Section 6 it is explained how to enhance the value of a product by adding a service (a PSS).

In this section we will explain how to enhance the value of a product by optimising its quality. **The question is: can you improve the quality of a product, and reduce the costs (and eco-costs) of that product at the same time?** This issue is dealt with in so called 'value engineering' and Total Quality Management (TQM) by eliminating not only waste, but also 'wastage of quality' [22]. This is not only relevant for reducing costs, but also for reducing eco-costs, since costs and eco-costs go often hand-in-hand.

Value engineering began at General Electric Co. during World War II, when there were shortages of materials and skilled labour because of the war. People noticed that they should meet the product specifications (the 'value') at minimum usage of materials and labour (minimum costs). Value engineering is about the cost-effective use of materials and labour in order to optimise a product in its functionality. It is achieved by:

- Analysing the contribution of each subcomponent to the functional requirements of the total product
- Substitution of each subcomponent by another solution, reducing costs without a serious adverse effect on overall functional quality of the product.

---

[22] It is obvious that it is fully in line with sustainability. Many success stories in literature on 'saving the environment and at the same time saving of money' stem from TQM projects. In TQM, enhancing productivity is the main aim; however, a positive effect on the environment is often a welcome 'by-product'.

In TQM, the idea of value engineering of costs-effective design was brought one essential step further. In value engineering the issue of value is the issue of functional quality. In TQM the issue of value is the issue of 'customer perceived value', so the value in the eyes of the customer. TQM is about eliminating of 'non-added-value waste and work', where value is the value in the eyes of the customer. Here, the notion of 'wastage of quality' comes in: when a part of a product has high functional quality, but it is not seen by the customer as important, it is 'wastage of quality'. The quality of such a part is not effective in the sense that the customer doesn't value it. This principle is depicted in Fig. 7.1.

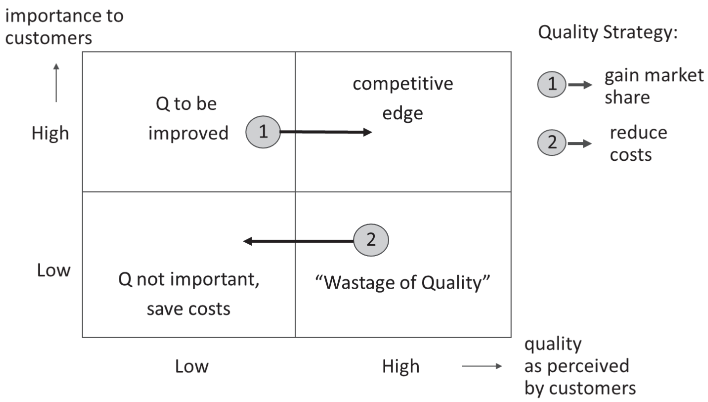


Figure 7.1

Improvement strategy of the quality dimensions of a product by reducing quality that is not important to the customer

An analysis of 'wastage of quality' starts with a customer survey, which provides data on both aspects of it:

- the quality as perceived by the customers;
- the importance of that quality dimension to the customers.

The improvement strategy is then easily defined:

1. gaining market share by improving the quality of the dimensions which:
    a. are important to our customers;
    b. have a low perceived quality.
    (see arrow 1 in Fig. 7.1)
2. reducing costs for the 'wastage of quality' dimensions which:
    a. are not important to our customers
    b. have a high quality
    (see arrow 2 in Fig. 7.1)

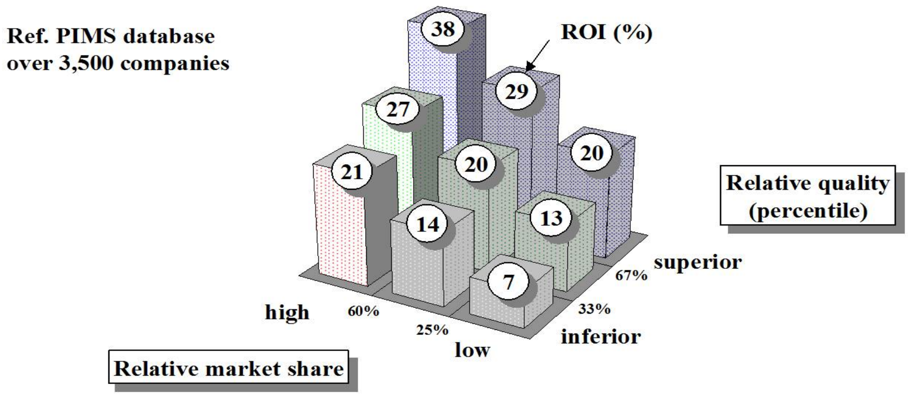
It is obvious that aforementioned strategy can also be applied to subcomponents of a product or PSS. Note that the essence of the strategy is that you invest in other issues then you save money (resp. in 'competitive edge' and in 'wastage of quality'). There is a third option in the matrix of Fig. 7.1, which will be dealt with in the next section.

7.3 The theory on Managing of Customer Value

In his book 'Managing Customer value', Bradley T. Gale has proposed a model for strategic management of the value of a product-service system in order to gain a maximum profit out of that value. This book has been written in 1994 after the PIMS study ("Profit Impact of Marketing Strategy"), a statistic analysis on 3800 American companies initiated by a General Electric and published in 1987. This PIMS study had revealed that the main drivers for company profits were 'relative quality' and 'relative market share', see Fig. 7.2.

Figure 7.2

Quality and market share both drive the profitability of companies. Note that ROI is 'Return On Investment' which is the ratio of profit and invested capital.



The route to a high profit is clear: via a high 'relative quality' (value), a high 'relative market share' can be achieved, resulting in a high ROI. But the question then is how to achieve a high relative value, being a high quality at the right price.

The key to this question is to focus on the quality dimensions (Section 7.1) that are important to the customers (Section 7.2). There are two options:

- either improve the quality of the dimensions which are important to the customers (and at the same time save costs by eliminating 'waste of quality')
- or try to influence the customer preferences in the direction of those quality dimensions of your own products which are relatively high in comparison to the competitors

The second option is often combined with the first. When a car manufacturer has developed a relatively safe car, this manufacturer has to make the market aware of this fact **and has to make it an important quality dimension at the moment of purchase.**

The theory of Gale is explained here by an example, providing the main methodology, its characteristics, and the philosophy behind this model[23].
The (slightly simplified) methodology comprises three steps:

- Step 1. Assessment of the 'perceived quality ratio' of the product-service system
- Step 2. Assessment of the 'perceived price ratio' and the 'fair price'
- Step 3. Assessment of the strategic consequences

Step 1. Assessment of the 'perceived quality ratio'
Since most of the strategic marketing analyses are confidential, we will use here a hypothetical example of vegetables, where a 'bio-vegetable' (no use of pesticides) is compared to the normal vegetable.
The comparison is made by a focus group or a customer survey, as to how they perceive the relative ratings (1 is the lowest score in rating, 9 is the highest score in rating). The results and the calculation scheme are given in Table 7.1.

Table 7.1

Calculation scheme of the weighted quality rating of a product

(1) Aspect	(2) Importance	(3) Q rating Bio-product	(4) Q rating Normal product	(5) ΔQ rating = (3) – (4)	(6) 'weighed' = (5) x (2)
Taste	0.2	8	6	+2	+0.4
Appearance	0.2	6	8	-2	-0.4
Health aspects	0.2	8	5	+3	+0.6
Presentation	0.1	7	8	-1	-0.1
Availability	0.2	6	8	-2	-0.4
Environment	0.1	8	5	+3	+0.3
Total	1.0	**7.1*)**	**6.7*)**		**+0.4**

*) This is the weighted average quality = sum of quality rating x importance

The 'perceived quality ratio' is now defined as:

$$7.1 \,/\, 6.7 \;=\; 1.06$$

so the bio-product is rated 6 % better in terms of perceived quality.
Note that this rating depends on the characteristics of the people in the focus group or in the survey. The Q rating as such in columns (3) and (4) don't vary much with the people in the focus group. The importance of column (2), however, is very sensitive for the type of people (and therefore the 'market niche' in which the product is launched). A different marketing strategy is needed for a different market niche.

Step 2. Assessment of the 'perceived price ratio' and the fair price
In this case the perceived price ratio is simple: it is the ratio of price of the new product compared to the price of the existing product. In other words, when the price of the

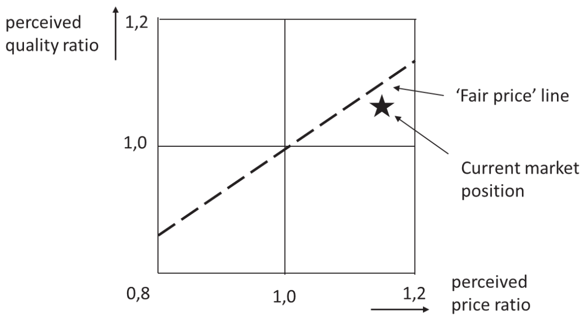
[23] The model has been linearized and slightly simplified to bring it in line with the wide spread methodology of the 'Decision Matrix'.

bio-product is 15% more than the price of the existing products, the perceived price ratio is 1.15 [24].

The market position of the bio-product (in relation to the normal product) is depicted in Fig. 7.3. The dotted line in Fig. 7.3 is the 'fair price' line (the WTP). It represents the value (in terms of money) of quality. Everything below the fair price line is perceived as too expensive; everything above the fair price line is perceived as attractive in terms of 'value for money'.

Figure 7.3

The 'fair price' line and the market position of a product



Let us assume that the focus group indicated that a maximum extra price of 10% for the bio-product was acceptable (WTP = 1.1 * price for the existing product). In other words: for the majority of the people on the panel a 'perceived price ratio' of 1.1 was just acceptable (as a maximum) at the 'perceived quality ratio' of 1.06. The fair price line is then a straight line through (x=1; y=1) and (x=1.1; y=1.06).

The actual perceived price ratio (1.15) of the bio-product is then too high in comparison with the value of the product.

The first reaction of most people is that the price has to be lowered (in Fig. 7.3, the market position of the bio-product has to shift to the left). Fig. 7.3 shows, however, that there is an alternative: increase the perceived quality ratio, either by increasing the quality or by influencing the perception (change the consumer preferences).

We will analyse these options for a market strategy in Step 3.

Step 3. Assessment of the strategic consequences

In the above example, there are three options to bring the product above the fair price line:

- lower the price by at least 5% by lowering the costs of production and distribution
- increase the quality of the product
- change the perception of 'what is important'

[24] The reason that it is called 'perceived price ratio' is that for many modern products the price is not so clear anymore, especially when it is a PSS (it is often not clear what part of the price is paid for the product and what part is paid for the service).

The first option seems simple, but is often hard to realize in practice. When the sales volume is higher, distribution costs can be lower, but when a lower price doesn't generate the required extra volume, this option doesn't work. In general one should take care that savings in production and distribution may not harm the product quality (otherwise one is acting 'pound foolish – penny wise'). Savings are only allowed in aspects which are not important to the customers. However, in this case there are no such opportunities.

The second option is more promising, especially when it is focussed on quality aspects which combine:

- a low score for the 'Q rating' ,column (3) of Table 7.1
- a high score for 'Importance' ,column (2) of Table 7.1

In this example this is the case for 'Availability' and 'Appearance'.

The third option seems to be the most attractive from the point of view of strategic marketing. The strategy here is to focus on the quality aspects with the highest scores: 'Taste', 'Health' and 'Environment'. The aim is to increase the 'Importance', column (2), as perceived by the customers. In other words, when the 'Importance' of 'Health' can be increased from 0.2 to 0.3 and the 'Importance' of 'Availability' can be decreased from 0.2 to 0.1 (the health issue becomes so important that people are prepared to get the bio-product in a specialized shop), the scores in Table 7.1 will change as follows:

Q rating Bio-product: 7.3
Q rating Normal product: 6.4

The result is that the new 'perceived quality ratio' is 7.3 / 6.4 = 1.14
which is well above the fair price line.

The strategy of the third option is summarized as arrow 3 in Fig. 7.4.

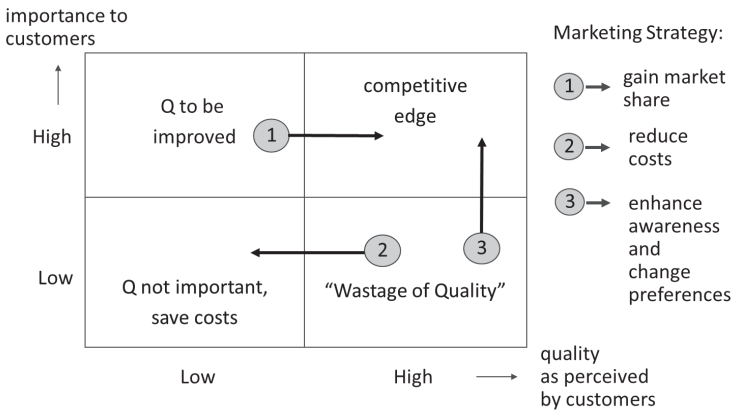


Figure 7.4

The market strategy of Gale adds a third option to the quality improvement strategies of Fig. 7.1

7.4 The theory on value of Kano

In the previous section, the relationship between quality and customer satisfaction (in terms of WTP) is assumed to be linear. Kano was the first to realise in 1984 that not all relationships between quality and customer satisfaction are linear. He distinguished 5 types of quality for the attributes of a product, of which the first 3 are the most important for designers, depicted in Fig. 7.5:

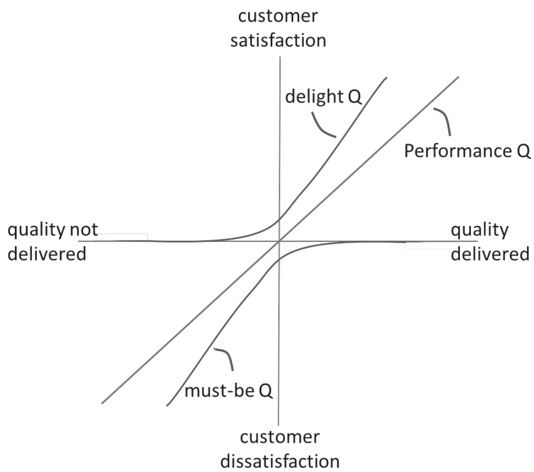


Figure 7.5

The customer (dis)satisfaction of must-be, performance, and delight quality

The 5 types of quality are[25]:

- **Must be quality, also called dissatisfier**
  This quality characteristic (or attribute) must be present; otherwise the customer will not buy the product and/or will complain. This quality characteristic is taken for granted when fulfilled, but results in dissatisfaction when not fulfilled.
  It is type 3 of the dimensions of Garvin, Section 7.1.
- **One-dimensional quality, also called performance**
  This quality characteristic (or attribute) is linear: the customer satisfaction has a linear relationship with the level of performance, and is positive at a positive performance and negative at a negative performance.
  It is type 1, 4, 5, and 6 of the dimensions of Garvin, Section 7.1.
- **Attractive quality, also called satisfier, or delighter**

[25] For a practical application of the theory of Kano see Wever R, Lotgering S, Ruijs F. 'Green Marketing of Consumer Electronics: Applying Kano's Theory of Attractive Quality on EcoDesign' available at www.ecocostsvalue.com.

This quality characteristic (or attribute) causes satisfaction (even delight or excitement) when it is present. Often it is not expected. Since it is not regarded as needed, it does not result in dissatisfaction when it is not present.
It is type 2 of the dimensions of Garvin, Section 7.1.

- **Indifferent quality**
  This is the type of quality which is not valued by the customer.
  It is the 'waste of quality' type of Section 7.2.
- **Reverse quality**
  This is the type of quality (or attribute) that is not wanted by the customer of a certain market niche. It is often in the field of type 2 of the dimensions of Garvin, Section 7.1. (example: too much options on electronic equipment, since certain customers want simplicity)

Bradley Gale realized that the factor time plays a role in the Kano model. In the course of time the characteristics of specific types of quality shift from delight, to performance, to must-be. Gale introduced the 'stages of the attribute life cycle' for a product type, and related that to the desires of customers:

1.	Latent:	Not yet visible or apparent	delight Q
2.	Desired:	Known but not currently supplied	delight Q
3.	Unique:	Only the pioneer scores well	performance Q
4.	Pacing:	One supplier is already ahead	performance Q
5.	Key:	Differences in performance determine competitiveness	performance Q
6.	Fading:	Declining importance a competitive edge	must-be Q
7.	Basic:	All suppliers perform well, no competitive edge	must-be Q

It is important to realise that this shift over time of the characterisation of the same type of quality is mainly valid for the type 2 of the dimensions of Garvin, Section 7.1.
For type 1, 4, 5, and 6 of the dimensions of Garvin the performance character of quality seems to remain competitive edge over time, requiring ever higher performance standards, and sometimes requiring adaptation to new trends in society.
Type 3 of the dimensions of Garvin is always a must-be quality, regardless of the stage of the product type life cycle.

8 Green marketing

8.1 The Double Filter Model and the Double Benefit marketing of green products

In Fig. 1.3 it is explained why every company has to reduce the eco-costs of its products: the 'pollution for free mentality' will not be accepted in future, so the eco-burden of products will be 'internalised' via the mechanism of prevention costs. This argument is about risk of future costs.

The challenging question, however, is whether or not it is possible to make extra profit by the marketing and communication of the fact that products are green:

1. either by asking a higher price for a green product,
2. or by attracting more buyers (i.e. selling more products to existing buyers and/or attracting new buyers).

The problem of option 1 is that most buyers do not pay more for a green product[26]. In Section 1.3 two reasons have been given that they do not value 'green' in terms of Willingness to Pay (WTP):

- consumers tend to think only about short term benefits at the moment of the purchase; a long term, complex, and 'far-away' issue like the environment is not part of their rather impulsive and intuitive buying process
- even when consumers think about sustainability, most people are not altruistic: they are not prepared to pay extra when other people don't

Only 2 – 6% of the buyers[27] are prepared to pay more than 10% extra[28], which indicates that **green products can only be sold at premium prices in the green niche markets**.

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[26] Green products are defined here as "products which minimise environmental pollution and materials depletion, so that they can meet the needs of the present without compromising the ability of future generations to meet their own needs". In such a strict definition 'green' (the environmental benefit) is clearly separated from other aspects of 'value' (the personal benefit), like personal health, happy family life and other 'feel good' factors, and saving money by energy savings.

[27] It seems that these buyers are 'egalitarians': people who tend to place their own personal benefits not above the personal benefits of others. See Appendix X. Unfortunately egalitarians represent only a small proportion of mankind.

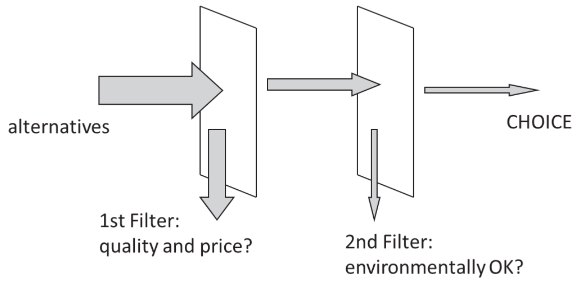
[28] Four references from the period 1996 - 2000 are provided in [4, page 131]. Recent evidence was found in the experiment described in footnote 4 at page 8. New evidence is also found in the PhD research of Mirjam Visser, which will be published in due course. This PhD research gives an analysis of a large database on customer satisfaction, covering data on worldwide collected data from 17,000 owners of vacuum cleaners, irons and coffee machines, comprising 17 different manufacturer brands.

A more promising opportunity in terms of impact on our environment might be option 2: attracting **a higher sales volume in mass markets**. This is in line with several enquiries [4, page 135, 136] (see also footnote 4 at page 8) which show that over 80% of the people indicate that environmental protection is rather important to them. Although environmental protection is not a top priority, these people are inclined to buy green products, **under the condition that they are not more expensive, and that the quality is not less.**

From an experiment on product selection [1, Section 7] [4, Section 8 and Section 9.4], it appeared indeed that the environmental aspects play only a secondary role in the final choice, as depicted in the Double Filter Model[29] of Fig. 8.1.

Figure 8.1

The Double Filter Model



When the value/price ratio already leads to a conclusive choice, customers do not take environmental aspects into consideration anymore. However, when there is no preference on the basis of value/price, the environmental issue (the 'environmental benefit') does help consumers make their final choice[30].

This gives an enormous opportunity in commodity markets, with competition on price, where it is not easy to differentiate. In these markets, environmental aspects provide the opportunity of a competitive edge, not to aim at a higher price, but to aim at a higher sales volume.

An example of a commodity market is the consumer electricity market with 'green electricity'. In 2009, 39% of the Dutch households purchased green electricity. An additional 27% indicated that they were willing to shift to green electricity when the additional price would be less than 10 euro (3%) per month (study NMA in 2009).

However, it appeared in the experiment of footnote 29 that the Double Filter Model is not only valid in commodity markets (where the price is the primary criterion for

[29] This Double Filter Model resulted from an analysis of the buying behaviour of 28 individuals. It was first published in Journal of Cleaner Production in 2002, title "Communicating the eco-efficiency of products and services by means of the eco-costs/value model". (Scopus reference count, 2012, was 37)

[30] The reality is a bit more complex than the Double Filter Model shows: consumers often restrict their selection process to a limited number of brands (they start with a so called 'set of considerations'). Section 8.3 shows that giving a brand a 'green' connotation might be a preferable communication strategy, rather than green labelling of products.

choice), but also in markets of quality products where value/price ratios are the primary selection criteria. In these mass markets it is also not possible to get a higher price, but to get a higher sales volume by having an advantage at the 2nd filer step of Fig. 8.1. Product labelling can sometimes provide this advantage, provided that the high quality of the product is emphasised, as will be explained in Section 8.3.

With regard to marketing strategy, this suggests that it makes sense to distinguish between 3 marketing issues:

- the issue of the type of benefit:
  - 'Personal Benefit', related to customer (perceived) value
  - 'Environmental Benefit', related to the long term issue of eco-burden[31]
- the issue of the size of the market:
  - environmental niche markets, aiming at people who are prepared to pay more for a green product
  - mass markets, aiming at the total population that can be influenced in its final choice
- the issue of the type of competition:
  - markets with price competition (commodity products, like milk, electricity, fuel)
  - markets with competition based on quality (quality products, like cars, apparel, ICT, mobile phones)

Fig. 8.2 depicts the resulting 4 market strategies. The 'Double Benefit' strategy is a strategy where the Environmental Benefit is linked to the Personal Benefit in the communication about the product. See also [4, page 138 and Annex 9b] and Section 8.3.

	competition on price	competition on quality
environm. niche markets	Environmental Benefit Strategy, 'Added Price'	Double Benefit Strategy, 'Added Value'
mass markets	Environmental Benefit Strategy, 'Added Volume'	Double Benefit Strategy, 'Added Volume'

Figure 8.2

The environmental marketing strategies

[31] Note that the two dimensional approach of distinguishing between the personal and the environmental benefit is fully in line with the model of the EVR, with the two dimensional approach of the eco-costs and the value of a product. This two dimensional approach in marketing, with the Double Benefit strategy was first suggested in 1993 by Jacquelyn A. Ottman in her book "Green Marketing".

Note: The 'Double Benefit' is also called 'Linked Benefit' in literature[32].

In markets with price competition, the Environmental Benefit allows higher prices in *environmental niche markets,* however, only higher volume (at the same price) in *mass markets*. In markets with competition based on quality, the Double Benefit strategy allows higher value *in environmental niche markets,* however, only higher volume in *mass markets*.
It is important to realize that products, competing on quality in *environmental niche markets,* need to have the environmental benefit, however, in addition to that, need the personal benefit as well. The Willingness to Pay extra for the environment in the environmental niche markets, will work only when the other aspects of customer value are present as well.
Referring to the theory of Kano (Section 7.4), the environmental benefit is first a 'delight quality'. Later it becomes a 'performance quality', and after some years it is a 'must-be quality' (example in fashion: replacement of natural fur by synthetic fur).

Double Benefit strategy should be more than the simple "energy savings will save on costs as well as eco-costs". PV cells, for instance, should be marketed with reference to 'clean air and nature' plus 'reduction of carbon footprint'. The clean air links to the personal benefit, the carbon footprint links to the environmental benefit.

Some examples of companies which are good at Double Benefit marketing by instinct:
- The Body Shop: beauty products which are good for the skin (personal benefit) linked with ethical aspects as sustainability (environmental benefit)
- Prius introduction in the USA: they gave colourful painted cars to celebrities, linking the feeling of belonging to the progressive jet-set (personal benefit) to the carbon footprint advantage (environmental benefit)
- BMW Efficient Dynamics: with "less emissions, more driving power"
- Volkswagen BlueMotion Technologies: with "enjoy cleaner, greener driving" (enjoy driving = personal benefit; cleaner and greener = environmental benefit); from the German website: "Individuelle Mobilität erhalten (personal benefit) und dennoch gesellschaftlich verantwortungsvoll handeln (environmental benefit)"

Jacquline Ottman (footnote 31) suggests in her book that the best communication strategy is to link the Environmental Benefit to the corporate image or the brand identity - rather than link it to the product itself - and to link the Personal Benefit to the product. The logic behind this is that the personal benefit of the product is directly

[32] We use 'Double Benefit' in this book is because of the fact that 'Linked Benefit' is used in the insurance market as well, which might cause confusion. The following literature on the subject is recommended: Wever R, Goemans M, Bork S, 'Dissemination of the Linked-benefit Strategy in Sustainable Marketing'. available at www.ecocostsvalue.com

related to the short term consumer behaviour in the shop (buying on the basis of the best price/quality ratio). The environmental benefit supports then the feel-good effect after the purchase - back home - resulting in a high brand loyalty.
Ottman's additional argument is that the environmental benefit cannot be a 'nine-day wonder', and must be embedded in the corporate strategy to avoid the risk of a backlash in image. A corporate green brand seems to be more credible to the consumer than a single product.
Examples of a long term environmental communication strategy are Body Shop (corporate identity), BWM Efficient Dynamics (brand identity) and Volkswagen BlueMotion (brand identity). Well defined and well organised Green Labels fall also in this category, see next section. All these examples combine a green brand with a high quality product.
The experiment on the communication around BATA shoes in Section 8.3 confirms the hypotheses that the environmental benefit can better be attached to the brand than to the product: such a strategy results in a higher buying intention.

8.2 Negative and positive connotation of sustainability

8.2.1 The challenge: switching between awareness and action

The big challenge of sustainability is that something has to be done to change the current unsustainable trends. In the culture of our western world, which is dominated by individualism (see Appendix X) and democracy, people must be convinced to change their behaviour and take action.
The general way to convince people to take action is to follow the so called AIDA strategy. AIDA stands for the 4 consecutive levels in the mind-set op people:

- A. attention is the first level to achieve: when there is no attention, the issue doesn't exist in people minds, and nothing will happen
- I. interest is the second level to achieve: it is the level where people want to know more about the subject
- D. desire is the third level: people see that there is a better future
- A. action is the required stage: people take their future in their own hands and take action

Note: AIDA is used by many consultants in their presentations: they build attention in the first 5 minutes, they create a mutual understanding (interest) of the existing situation in the first half of the presentation, then they sketch a desirable future situation, and they invite the listener to take (plan) further steps in the last 5 minutes.

The first two steps of AIDA are related with building of awareness. The last two steps are related with implementation of action.

The problem with sustainability is that the *awareness* is built by describing a gloomy future (e.g. the movie "an inconvenient truth" of Al Gore), making people inconvenient with the current situation, and giving sustainability a negative connotation. See also Fig. 8.3.


Figure 8.3

The negative connotation of sustainability caused by awareness building

The problem with such a negative connotation is that it is counterproductive in the *implementation* of sustainability: the marketing of green products. When people buy a product, the product should have a positive connotation: people want to be happy with the products they buy. This makes the negative image of sustainability, created in the awareness stage, inherently unsuitable for marketing.
For marketing of sustainability, the connotation has to be switched from negative to positive: from feeling unhappy and responsible to 'feel happy', 'feel good', see Fig. 8.4.


Figure 8.4

The positive connotation of sustainability needed in marketing: conservation of a beautiful nature

The complex issue here is that NGOs want to make the people aware that we are lagging behind, where, at the same time, front running companies want to sell green products to people who are already convinced that we should take action.
Note: The debate on the pros and cons of the negative and the positive connotation of sustainability seems to be heavily influenced by the differences in paradigm between the

'individualists' (the perspective of business people) and the 'egalitarians' (the perspective of most environmentalists), as described in Appendix X.

There are two other issues related to a negative connotation of green products: the mistrust of green labels and suspected lack of quality (see footnote 4, page 8). These issues will be dealt with in the next two sections.

8.2.2 Green labels; do we trust them?

Over more than two decades, many marketers have tried to exploit the issue of the environment as an easy way to sell their product (so called 'green washing'). They took advantage of the fact that sustainability was (and still is) not well defined. The issue is that often:

- a product is only in one aspect good for sustainability, whereas all the other aspects are obviously not good at all
- a product is better than the product of competitors, but the whole product group is obviously bad in terms of sustainability
- the sustainability claim is hard to check and is made by some companies who are mistrusted in terms of sustainable behaviour

The overall result has been rather devastating: under the general public there is a high level of mistrust. This misuse of sustainability in marketing should be stopped, but how?

This problem is rather big in the field of green labels: apparently it is easy to design a label and stick it on a product, without taking any responsibility to underpin the claim with real, transparent information. The result is negative: a majority of people do not believe labels, or mistrust them (even to a level that products with green labels seem to be boycotted by certain people, see footnote 4, page 8). The damage has been done, and the main issue is how the regain trust when introducing a new label.

The solution seems to be:

- develop a new label not alone, but together with other companies in the same industry
- involve the full supply chain, since a lot of unsustainability is often caused in the supply chain
- involve NGOs
- establish an independent certification system, with tracking and tracing in the supply chain, and a good control system
- be transparent
- do not overstate
- educate and involve the public

FSC (for wood), MSC (for fish) and UTZ (for coffee) labels seem to be good examples of this approach. These labels withstand the critics of shortcomings by transparency, and seem to be trusted by the public.

8.2.3 The issue of the quality of green products

Quality is an important issue in the marketing of green products: it is not taken for granted that green products have the same quality level as normal products have (see footnote 4, page 8).
There are two issues:

- A lot of green products in the 80ies and the 90ies were green indeed, but had inferior quality. Materials like jute, cane, ramie, et cetera, were applied in products which needed strong modern materials instead. Writing paper out of waste paper had no quality, and municipal waste was downcycled in inferior materials. The claim of environmentalist that one had to accept the lower quality for the sake of the environment only emphasised the issue. The philosophy of 'less consumption' wasn't followed by the majority of people.
  Modern green products don't suffer from less quality, but there is still a bit alive of this poor image.
- It is widely known that sustainable production is possible, however, at (slightly) higher costs. There is general disbelief that green goes hand in hand with lower costs ("otherwise we wouldn't have a problem"), so the claim of environmentalists ("the greening of production saves money") is not believed and has a backlash.
  The result is that people mistrust quality: they think that the extra costs of making production green are compensated by the lower costs of lower product quality (aspects which don't show immediately, like durability).

The remedy is simple: green products should be marketed as high quality products, which cost a bit more, but last longer. So the quality of green products must be accentuated in marketing, to counteract the negative image. The claim of higher quality must be proven in a transparent way and not be overstated.
Companies like BMW and Volkswagen, which are leading in technical quality, are well trusted in terms of technical quality of their products, since nobody believes that they would jeopardise their high quality image. So, these companies have an advantage in the marketing of their green cars.
Note that this is fully in line with the general philosophy of the EVR model and eco-efficient value creation: products must combine low eco-costs with high value.

8.3 Case: an experiment with the communication of a sustainable shoe

The customer perceived value of a product is highly influenced by the marketing and communication around that product.
The issue is how we should promote green products and/or green brands. What should be avoided and what are the opportunities?
With regard to Section 8.1 and 8.2 the following questions are to be resolved:

- Does the Double Filter Model of Fig. 8.1 hold for other products than applied in the tests as described in [1, Section 7] [4, Section 8], i.e. is the fact that a product is green only of secondary importance to the average buyer, and is the WTP for a green product not significantly more?
- Is the Double Benefit strategy right, and is it better to create a green brand than to label individual products as green, as stated in Section 8.1?
- Can the negative connotation of sustainability as mentioned in Section 8.2 be underpinned by measurements?

Since there are hardly available data in literature on how much the greening of a product might add (or might not add) to the customer perceived value, it was decided to start research on this issue[33]. The research was part of the design of a green shoe for BATA shoes (BATA International is a global shoe manufacturer and retailer, see www.bata.com).
To test the perceived extra value of a green product and a green brand, an experiment was done in 2012 with the 2nd year bachelor students of the Industrial Design Engineering Faculty of the Delft University of Technology. A total of 688 students were invited by e-mail to fill in a web-based questionnaire with two parts, of which respectively 33.5% responded.

In one part of the questionnaire, students were asked to indicate which characteristics of shoes influenced their buying decision: 183 students filled in this questionnaire. They had to rate the importance of seven characteristics (price, brand, authenticity, quality, foot health and looks) on a scale (1=very unimportant, 5=very important).
The results of the respondents show that most of them indicate most characteristics as "important", see Fig. 8.5. Exceptions are the looks (which were indicated as "very important" by most respondents) and sustainability (which was indicated as "indifferent" by most respondents). Only 3 of the respondents, which is 1.6% (!), indicated that sustainability was "very important".

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[33] This section is a summary of "Communicating Sustainable Footwear" of Rosan van der Helm, 2012 (Mentors: V. Gattol and J.G. Vogtländer). This document is a part of a Master graduation report, and can be found on www.ecocostsvalue.com, tab 'data'. Tables and more details are given in this document.

Figure 8.5

Consumer priorities for attributes of shoes: number of respondents per category (183 students)

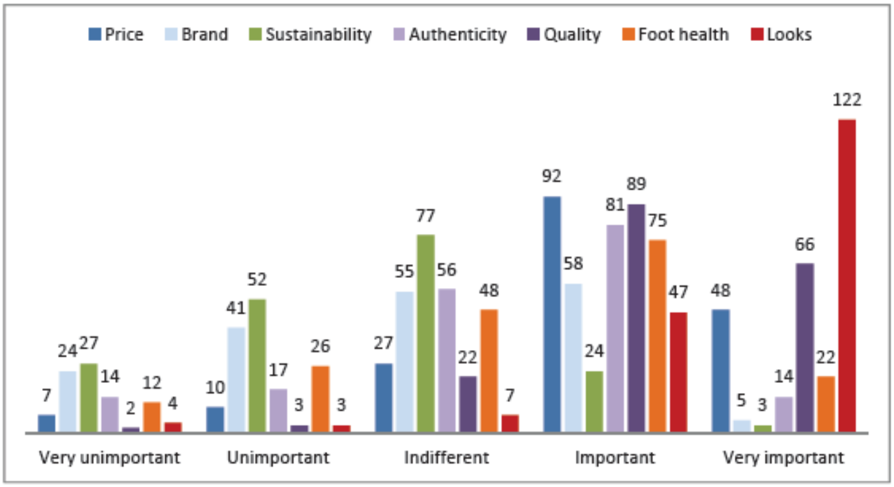
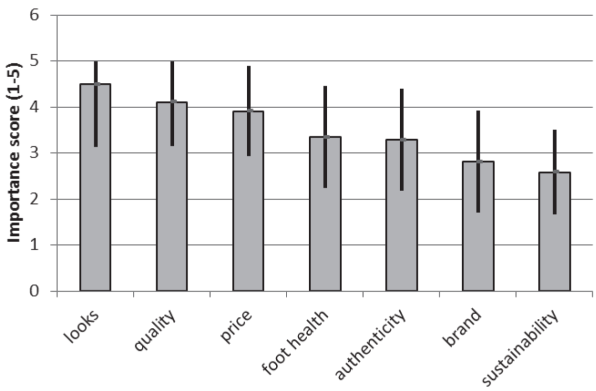


Fig. 8.6 shows the mean values and standard deviations of all characteristics (1=very unimportant, 5=very important). As can be seen from this graph, "looks" scores highest and "sustainability" scores lowest.

Figure 8.6

Consumer priorities for attributes of shoes; means and standard deviation (183 students)



The other part of the questionnaire had to do with the customer perception of communication. The research issue here is how an advertisement on a shoe can influence the perception of the shoe and the brand. Two aspects are important for this experiment:

- BATA shoes are not distributed in the Dutch consumer market, so most of the students were not familiar with the brand name
- It was decided to show only a rough sketch of a general shoe, to avoid that the design of the shoe would influence the answer, so that the design of the advertisement as such was dominant

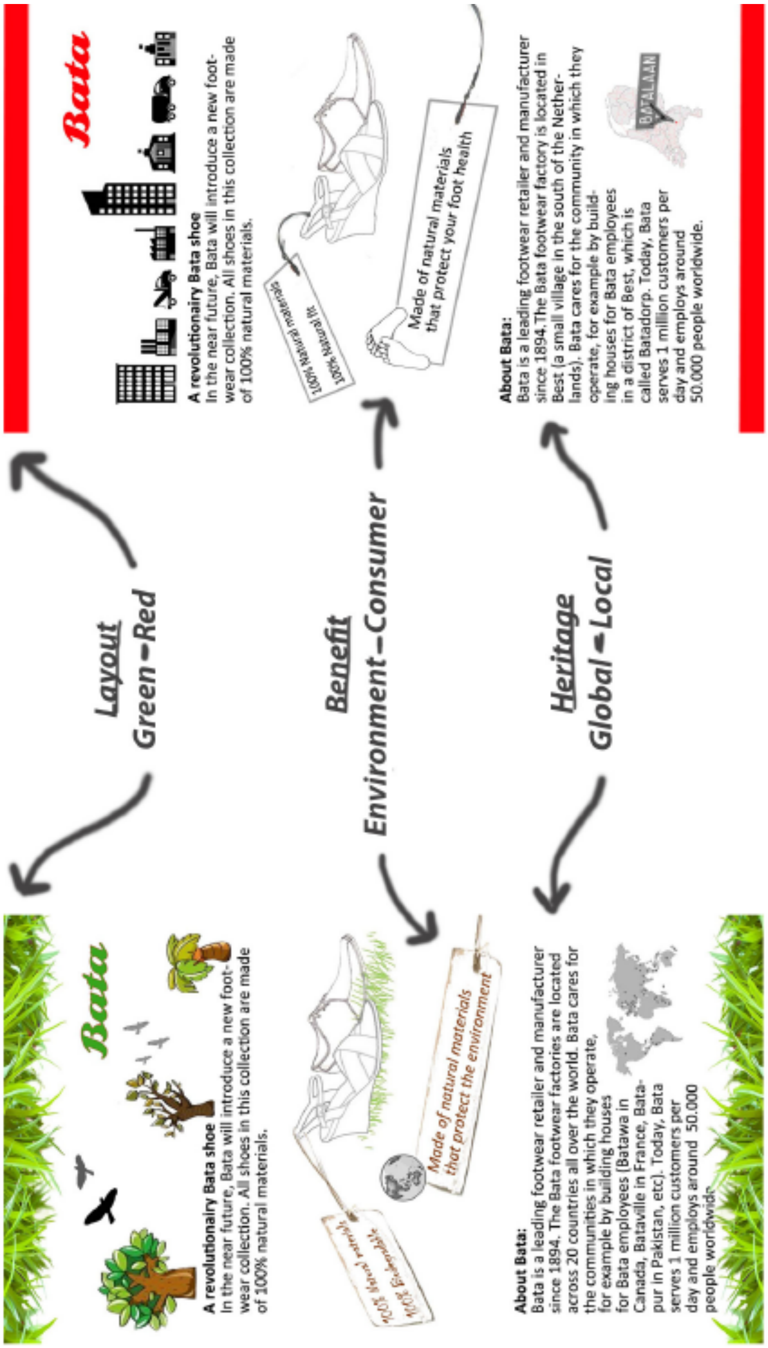


Figure 8.7

The basic idea of the experiment: 2x2x2=8 different advertisements, each given to a group of at least 20 randomly selected people

The research was designed as an experiment, based on a 2×2×2 factorial study with the following 3 variables, see Fig. 8.7:

- Layout: the 'background images', depicting the brand advertisement.
  Two types of images were chosen: a green image (dominating green colour with birds, flowers and trees), and a red, cosmopolitan, image (dominating red colour with a background of city buildings)
- Benefit: the characteristic feature of the shoe.
  Two types of features were chosen: a personal benefit (the health of your feet), and an environmental benefit ("this shoe protects the environment")
- Heritage[34]: the origin of the product.
  Two types of heritage were chosen: a local heritage (the shoe is made in the country, in a factory which stems from more than a centuries ago), and a global heritage (suggesting a modern global production and distribution company)

The basic idea of the experiment was to combine the 3 variables in 2x2x2 = 8 different advertisements, see Table 8.1. Each advertisement was shown to a **different** group of randomly selected students. A student did not see the other advertisements. Each individual student was asked the same questions on the product and the brand. The questionnaire was web-based.
The questionnaire was completed by 231 participants (51% women). For each advertisement 79 randomly selected students were asked by email to join the experiment. The participants had the age of 19-25.
During the data processing, 31 respondents were excluded because they did not answer all the questions. Consequently, the results of this study are based on the answers of 200 participants. Since the invitation was random and voluntary, the response differed per advertisement, ranging from 20 to 40 respondents per advertisement.

Table 8.1

The 8 advertisements of the experiment

advertisement number	brand	product	heritage	number of respondents
	Green layout			
❶		Benefit environment	Local	24
❷			Global	20
❸		Benefit consumer	Local	40
❹			Global	24
	Red layout			
❺		Benefit environment	Local	25
❻			Global	22
❼		Benefit consumer	Local	20
❽			Global	25

There were two key questions:

[34] The issue of heritage was included in the experiment, to check the suggestion in literature on sustainability that 'local' is perceived as better than 'global'

- “What is your buying intention?” (on a 1-5 scale: I will DEFINITELY NOT buy these BATA shoes, I will PROBABLY NOT buy these BATA shoes, I MIGHT buy these BATA shoes, , I will PROBABLY buy these BATA shoes, I will DEFINITELY buy these BATA shoes)
- “Which price are you prepared to pay?” in combination with another question “What is the mean price you pay for shoes?”, resulting in a relative price of the BATA shoe. (A relative price of higher than 1 indicates that the WTP of BATA shoes is higher than the WTP for the average shoe.)

The results of these two questions are depicted in Fig. 8.8 and 8.9.

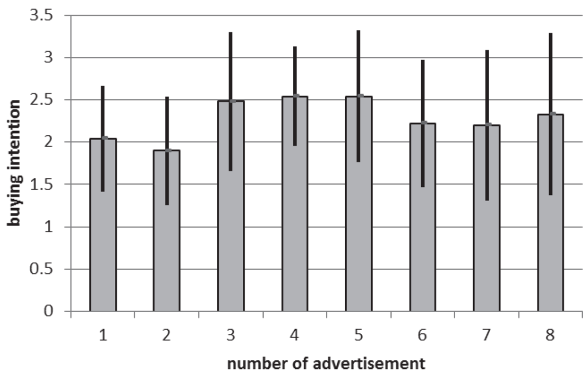


Figure 8.8

The buying intention (mean and standard deviation) for each type of advertisement; for advertisement number see table 8.1

Although the ratio of ‘standard deviation’/‘mean’ of the buying intention is quite high, the main picture is clear:

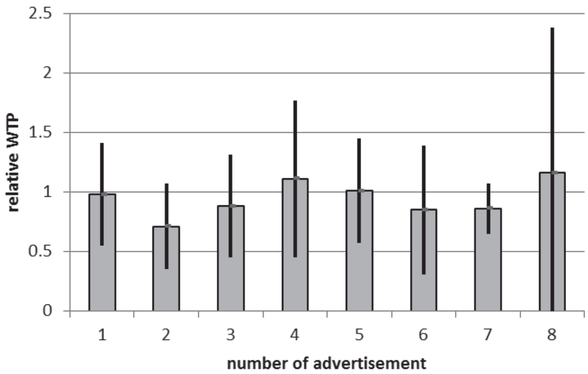
- the combination of a green layout (a green brand image) with a personal benefit (advertisement 3 and 4) scores statistical significant (p=0.004) better than a green layout with an environmental benefit (advertisements 1 and 2)
- the combination of a red layout (a cosmopolitan brand image) with an environmental benefit scores better in advertisement 5, however not better in advertisement 6 (there were no statistical significant difference for the score on environmental benefit)

The data of Fig. 8.8 suggest that the Double Benefit marketing strategy of Section 8.2 seems to work: a combination of a green brand and a personal benefit results in a high buying intention. Note that the instinct of environmentalists to underline the environmental aspects as the main and sole message in the advertisement, like advertisements 1 and 2, seems to be the wrong marketing strategy.
The situation with the red layout (cosmopolitan brand image) is more blurred. On the one hand the combination with a green product seems to work, but only when it is combined with local heritage? In this study, there was no indication that local heritage scores better than global heritage on average, so the successful combination of green and local has to be studied further before any conclusions can be drawn.

The experiment also showed that the simple questions on the WTP generated too much spread to enable further analyses, see Fig. 8.9. Apparently, the WTP can only be determined by comparing a prototype with several existing product solutions (i.e. by ranking). The experiment seems to confirm that students in general will not pay more for the fact that a product is green (advertisement 1, 2, 5 and 6).

Figure 8.9

The relative WTP (mean and standard deviation) for each type of advertisement; for advertisement number see table 8.1



With respect to the issue of quality of green products (Section 8.2.2), the experiment shows a negative connotation of quality with respect to green on brand level, as well as on product level.

On brand level the perceived quality was tested by the following questions: "BATA serves the high end market", "BATA is a luxurious brand", "BATA sells expensive shoes" on a scale 1 – 7. These questions revealed the following statistical significant difference (p=0.029):

- Green layout: mean score 3.61 (standard deviation 1.02)
- Red layout: mean score 3.97 (standard deviation 1.19)

On product level the perceived quality was tested by the following questions on durability: "The shoes are durable", "The shoes are long-lasting", "The shoes are of good quality" on a scale of 1 – 7. These questions revealed the following statistical significant difference (p=0.016):

- Environmental benefit: mean score 3.87 (standard deviation 1.13)
- Personal benefit: mean score 4.19 (standard deviation 0.91)

Apparently, the perceived quality is less for green brands and green products.

The conclusion is that the quality aspects, like the durability, of green product must be highlighted in an advertisement to counteract the negative expectation, as already mentioned in Section 8.2.3.

9 Corporate investment strategies

9.1 Awareness of business opportunities

The word awareness in sustainability has normally the negative connotation as described in Section 8.2. It is about a gloomy future when nothing is done (the egalitarian paradigm of Appendix X).
The required greening of production and consumption to cope with the growth of the world population and the growth of prosperity in fast developing countries like China and India, however, is regarded as an opportunity by entrepreneurial business managers (the individualistic paradigm of Appendix X). This awareness of sustainable business opportunities is a topic in modern strategic consultancy.

Mc Kinsey & Company has written 3 comprehensive reports on the subject. The first report ["Resource Revolution: meeting the world's energy, materials, food, and water needs", 2011] is on the issue of resources (materials, food water) and climate change (the need for renewable energy). The gloomy problems (the "challenge") are converted into business opportunities. See Fig. 9.1.

Figure 9.1

The business approach to a changing world
Source:
Mc Kinsey, 2011

The second and third report have been written under the guidance of the Allen MacArthur Foundation ["Towards the circular economy", volume 1 and volume 2, 2013]. The essence of these two reports is that it shows how companies can thrive in a future circular economy. It is, however, up to the entrepreneurial business managers to develop the specific innovative solutions and implement them.

The challenge is huge (as already stated in Section 1.1). A rough calculation on the average relative improvement of CO_2 emissions shows that we need a factor 7.25:

- a factor 2.5 to get the current excess of CO_2 emissions under control,
- a factor 2 to give everybody on the earth the same wealth as Europe has at this moment,
- a factor 1.45 for increase of population (the world population will stabilise in 2050).

For the detailed calculation, see www.ecocostsvalue.com, tab 'general' -> tab 'factor 4, 10 or 20?'
The required metals to support the economic growth until 2050 is also large (a factor 2 x 1.45 = 2.9), under the assumption that 100% of the end-of-life metals are recycled, which requires higher mining efficiencies, "deeper digging", and new mines.

One cannot be overoptimistic that our free market economy will resolve all these problems automatically. Governmental regulations are indispensable (see Section 1.3 Fig. 1.4, the 3 Stakeholders model). It is expected by most economists that the materials scarcity issue will be resolved by normal price mechanisms (higher prices will generate better material efficiency in mining as well as manufacturing, more recycling, and replacement by other, new materials)[35]. However, for reduction of emissions, there is no price mechanism in place, other than the mechanism described in Section 1.3. The main issue for business managers is the predictability and stability of governmental strategies. Politicians seem to struggle with a good balance between long term leadership and short term populism. The fact that governmental policies fluctuate, frustrates the required decisions on the long term investments in industry.

One should realise that big companies and small companies play a different role:

- Big corporations can execute big applied R&D programmes on system innovation and technological break-through, since these corporations have the financial strength to do so (e.g. the automotive and the electronics sector)
- SMEs have the flexibility of introducing innovative products and business models on a small scale, and are agile enough to experiment in niche markets with new circular business models

[35] Some environmentalists claim the threat that prices will rise with a high volatility (and they seem to be right), which will hurt the economy. On the other hand one might argue that current prices are simply too low for sustainable circular solutions in our society.

For both kinds of companies, the imminent changes in society are a challenge and opportunity for entrepreneurial action.

9.2 Business sector analyses, investments and disinvestments

For years, it has been a challenging idea to calculate the environmental externalities (i.e. the damage costs of emissions) of companies, and still it is. Several international attempts have been made to include the externalities in corporate accounting systems, and to introduce 'full-cost pricing'. However, calculating the damage of pollution is far from unproblematic [2, Appendix II]. The UseTox tables provide the best currently available estimates, but these tables are for average situations as used in LCA, not for specific cases, and these tables are not monetized.

A British consulting group called Trucosts Plc, however, has compiled all kind of damage based data, which are used to make companies aware of their external damage costs. Puma is the first company which made an Environmental Profit and Loss Account according to this method.
For corporate investors, investment funds, pension funds, et cetera, it is interesting to know the ratio of the external costs and the EBITDA (Earnings Before Interest, Tax, Depreciation and Amortization, which is an indicator for the net operational profit of a company). The major issue is here: "would this company still make profit, when it had to pay for its environmental damage?" KPMG has written a comprehensive report on this issue ["Expect the Unexpected", 2012]. See Fig. 9.2.

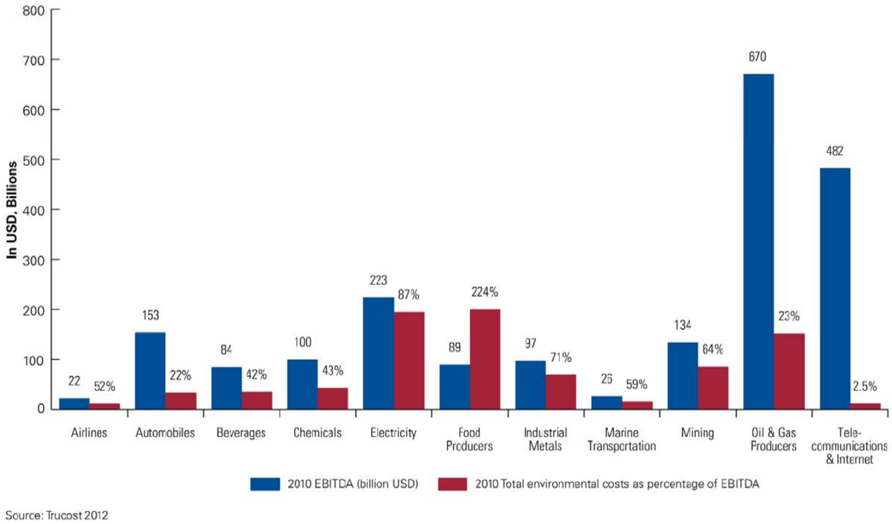


Figure 9.2

External damage costs and EBITDA per business sector Source; KPMG, 2012

The suggestion is made that investors can better avoid business **sectors** with a high external Costs/EBITDA Ratio. But it remains to be seen if such a suggestion does make sense, for three reasons:

- The predictability of damage costs is extremely low. Damage costs estimates have a confidence interval which ranges from a factor 10 in WTP (= Willingness to Pay) and WTA (= Willingness to Accept damage) studies, to a factor 100 or more in socio-economic costs estimates. So the bars in Fig. 9.2 suggest accuracy which is by far not there (these bars can even not be drawn, given the high confidence interval ranges).

  Trucost Plc made their own subjective choices in these wide ranges. They arrived at a sort of "Trucosts norm", which is not wrong as such, but would require more transparency on the calculation and on the subjective choices, to become acceptable in science.
- There is no direct price mechanism that converts the current external **damage** costs to internal costs in the future. There is the mechanism of Section 1.3, Fig. 1.3, (i.e. the "pollution for free" mentality of companies is less and less accepted by the society in general), that converts the marginal **prevention** costs of the pollution to internal costs. So Fig. 9.2 uses the **wrong parameter**: prevention costs should be used instead of damage costs. An advantage of prevention costs is that the confidence interval is about a factor 2, with a high transparency of the calculation.
- Given the growing population in our world, it is not likely that business **sectors** like the food industry and the airline industry will decline in size because of the fact that these sectors are polluting heavily[36]. It is likely, however, that heavily polluting **companies** within these sectors will disappear when other companies are less polluting, because of public pressure and/or the mechanism of Fig. 1.3. So, the comparison of Fig 9.2 does only make sense **within** a sector.

For investment funds and pension funds, the most promising strategy seems to be to invest in innovative companies in sectors with a fast growing market and a high level of eco-burden. When these companies become 'best in class' in their peer group (in their sector) with regard to sustainability they can become market leader in future[37].

An example is the race to develop the best technologies in the automotive industry, which was triggered by the 120 gram/kg target which was set by the EU. Another example is in the apparel industry, where Nike and Puma started to take action in their supply chains in order to make their products more sustainable.

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[36] In such markets, it is likely that future costs of tradable emission rights and/or BATNEC (best available technologies) requirements will be passed on to the consumers, like higher energy prices are passed on to the consumers at the moment. The issue is, that a company which has lower eco-costs, will have a competitive edge in future, since it can offer then lower prices at higher profit margins.

[37] In sectors with a high level of pollution, there will be a "shake out" of unsustainable companies which lose in the race of proactive improvements.

This strategic issue is depicted in the Sustainable Business Strategy Matrix of Fig. 9.3. [38]

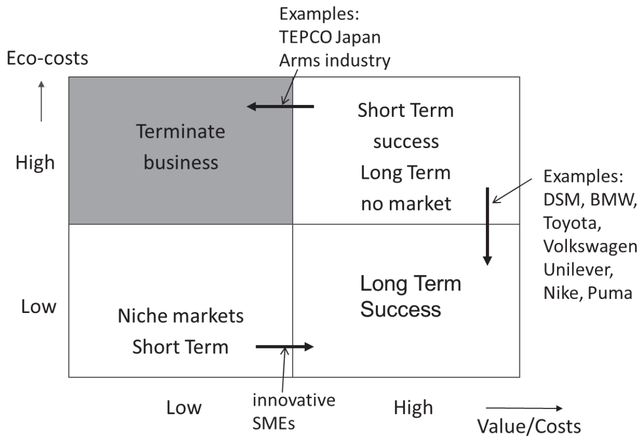

Figure 9.3

The Sustainable Business Strategy Matrix

An important issue is that the focus of sustainable improvement is specific for each sector. It is obvious that each sector should focus on the most important problems (opportunities) in their product chains (cradle-to-grave, or cradle-to-cradle). The petrochemical industry should focus on their core processes, the sector of the apparel industry should focus on improvements in the supply chain, and the automotive sector focusses on the use phase of their products. See Fig. 9.4.[39]

Reliable data on products for the upstream plus core processes have been calculated in the EIPRO study, and the related eco-costs are given in the Excel table on products and services which can be found at www.ecocostsvalue.com tab 'data' (see also Fig. 2.7, Section 2.3). However, these tables are made for consumer products, not for companies.

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[38] Note that the Sustainability Business Strategy Matrix deviates a bit from the EVR Decision Matrix for eco-efficient value creation as given in Appendix V. The difference is the x-axis. The EVR Decision Matrix for eco-efficient value creation has only the value at the x-axis, since the costs is not known at the early design stage. For companies, however, the Value/Costs Ratios of their products is key to making profit, either by having a big profit margin per product, or by selling a lot of products with an expanding market share (as explained in Section 5). Companies know the costs as well as the customer perceived value of their products.

[39] Figure 9.4 is the standard way to describe the interrelationships within the business chain in an Environmental Product Declaration (EPD):

- The upstream processes (cradle-to-gate), comprising the eco-burden of all companies in the supply chain (also called 'background processes')
- The core processes (gate-to-gate), comprising the processes within the fence of the manufacturing plant(s), plus processes which are outsourced under the responsibility of the manufacturer, plus the imported energy (also called 'foreground processes')
- The downstream processes (gate-to-grave), comprising the use phase of the product(s) and the end-of-life processes

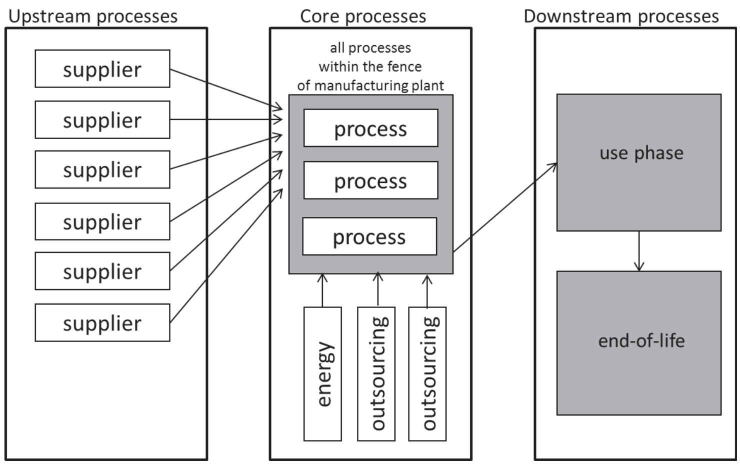


Figure 9.4

The core processes, the upstream and the downstream processes of a company

Reliable data on core processes (gate-to-gate) are available for manufacturing plants in the Netherlands. For the open access database, see www.emissieregistratie.nl. These data have been combined with financial data (Statline of CBS) in cooperation with IMSA consultants in Amsterdam, see Table 9.1.

The data in Table 9.1 are **gate-to-gate** (the core processes within the fence). Note that these data might be used in LCA calculations as well.
The data of Table 9.1 should be used to benchmark (compare) the pollution of a manufacturing plant with the average in the sector. Such a benchmarking study (as shown in Fig. 9.3) can be done to determine the own position relative to the position of competitors, but also to benchmark the performance of production plants within a multinational cooperation.

Table 9.1

Gate-to-gate EVR data on industry sectors in the Netherlands, 2010.

data in column 1, 2, and 4 in million euros	total sales	EBIT	% sourcing	emissions eco-costs	emissions EVR	emissions eco-costs/EBIT
gas and oil production	34843	7091	56%	160	0.01	0.02
meat	8209	262	75%	1	0.00	0.00
vegetables	4474	209	63%	12	0.01	0.06
dairy products	8845	425	76%	11	0.00	0.02
flour	2010	-4	68%	22	0.04	
animal feed	6194	237	80%	9	0.01	0.04
beverages	1388	154	57%	0	0.00	0.00
textile	2389	173	53%	26	0.02	0.15
leather	372	33	56%	4	0.02	0.11
wood processing	2676	112	53%	36	0.03	0.33
paper mills	5880	296	57%	258	0.10	0.87
printing industry	4534	184	42%	41	0.02	0.22
refineries	36713	172	91%	1751	0.56	10.18
base chemicals	34417	2879	68%	1916	0.17	0.67
fertilizer	2282	269	61%	842	0.96	3.13
plastics	9306	579	68%	95	0.03	0.16
paint	1719	115	57%	4	0.00	0.03
synthetic fibres	875	142	27%	14	0.02	0.10
rubber and plastic products	7114	520	51%	20	0.01	0.04
glass	1039	23	39%	16	0.02	0.68
concrete and prefab concrete	3109	95	54%	0	0.00	0.00
metals	8103	400	54%	28	0.01	0.07
foundries	591	12	47%	8	0.03	0.69
electro technology	14857	1495	66%	4	0.00	0.00
electric appliances	4818	307	60%	8	0.00	0.03
metal products	20706	2222	55%	27	0.00	0.01
automotive industry	6519	356	64%	15	0.01	0.04
shipbuilding	4428	445	70%	27	0.02	0.06
furniture	3417	189	52%	18	0.00	0.10
drinking water supply	1531	281	9%	2	0.00	0.01
sewage processing	653	26	39%	37	0.09	1.42
waste handling	1873	273	31%	1146	0.89	4.20
waste separation	1922	153	66%	14	0.02	0.09
building industry	83555	6537	57%	35	0.00	0.01
garages	44962	1264	79%	1	0.00	0.00
wholesale of products	370306	14532	78%	2	0.00	0.00
petrol filling stations	7633	141	87%	11	0.01	0.08

It can be concluded from Table 9.1 that some industry sectors are prone to the risk of "non-compliance with future pollution standards" (i.e. the eco-costs of their emissions). The table is for the gate-to-gate emissions (i.e. emissions from the specific production sites in the Netherlands); the table does not present data of upstream cradle-to-gate emissions of the products. Most industry sectors have a sourcing/sales ratio of over 50%. Given the fact that by far the most pollution is caused at the beginning of the production chain, special attention should be given to the pollution of the suppliers.

When Table 9.1 is used in further studies for competitive benchmarking within a sector, it should be realised that benchmarking is not only a matter of the relative position

within the peer group. The change rates of improvement projects and the timing of improvement projects are of crucial importance as well. Timing is important, because of the lead time of a significant improvement of eco-costs is rather long in a lot of business sectors. Companies which have to implement a sustainable strategy have to start pro-actively with their improvement programmes, in order to become front runners in the future race. The company must be profitable enough to be able to finance the related investment costs.
The issue of timing is dealt with in the next section.

9.3 Timing of improvement projects

The underlying philosophy in this book is that a strategy of eco-efficient value creation is the best strategy to survive in a sustainable future. Product innovation must lead to products with a higher customer perceived value at lower eco-burden (eco-costs). The higher value in the market creates a higher margin to cope with the extra production costs at the short term (Section 2.5). The challenge in design is that the extra value of the innovation creates enough profit to cover the extra costs of sustainable production.
In practice, however, there is often a problem with the timing of sustainable improvements projects of companies. Big quantum leaps in sustainability require big changes on system level, which requires extreme 'deep pockets' to bridge the gap between investments and earnings. There are many examples of companies which went bankrupt in cases where the investment appeared to be too big, and the earnings were delayed too much[40].

There are 3 drivers for change from the demand side (the market):

- More stringent regulations from governments (caused by a political will of citizens)
- More stringent specifications in the supply chain (caused by proactive corporations which have chosen to introduce innovative end-products, and use their buying power to achieve that in their supply chain)
- Rising awareness and changing preferences of the customer

The predictability of these 3 drivers is poor: trends are evident, but *when* specific changes will be triggered seems the result of many unpredictable events (so called 'black swans'). From the point of view of business planning changes should be slow, predictable, and stable. In practice, however, changes are sudden and unpredictable.

[40] An example is Plato wood. The process of "converting softwood to hardwood" by thermal modification was developed in the Netherlands in the 90ies. In that period there was a general awareness that the use of tropical hardwood should drastically be reduced. However, the Dutch government didn't implement more stringent regulations, so the company went bankrupt, being a big disappointment for the investors. The company had a restart and offers now an attractive product in the niche market of cladding and garden wood. But the rapid market expansion, triggered by more stringent regulations, didn't take place so far.

Fluctuations in governmental subsidies are often more harmful than beneficial to the sustainability change processes.

The issue is that lead times for sustainable innovation are rather long:

- The introduction of a new product: 1 – 3 years
- Building a new production facility: 2 – 5 years
- Development of a new technology: 5 – 20 years
- Replacement of existing systems by sustainable systems: 5 – 30 years (existing systems cannot be abandoned immediately: it would cause destruction of capital)

Long lead times require a business planning which is based on a long term corporate strategy. The best business planning is based on a step by step approach, to enable fine-tuning during the transformation process, and to keep the risk of a total failure to a minimum. In such an approach, product introductions by the appropriate marketing, and changes in production and in the supply chain, go hand-in-hand.

One of the issues is the cost efficiency of an improvement: the eco-efficiency (i.e. the reduction of eco-costs per euro real costs). It is obvious that a production company takes measures first that combine a large effect and a small investment. See Fig. 9.5.

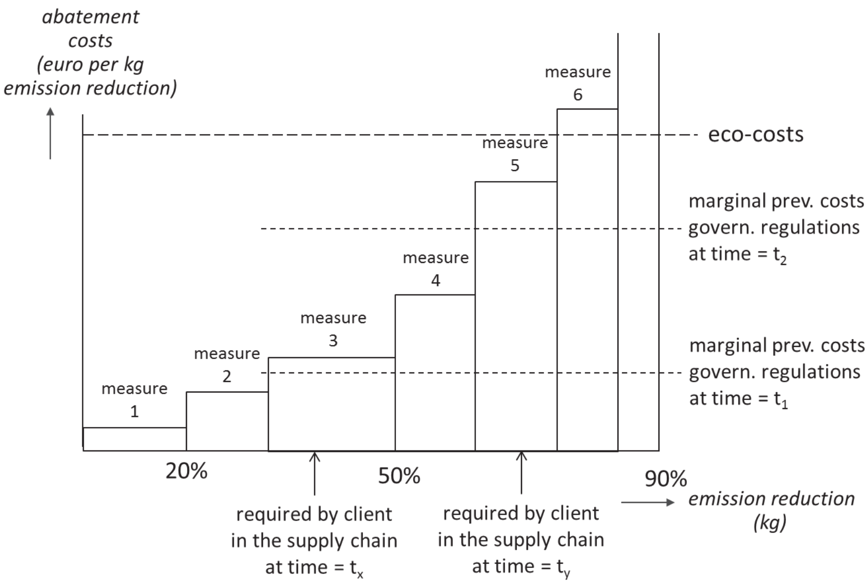


Figure 9.5

Priority setting of emission reduction measures by a company

Figure 9.5 shows a hypothetical case of a company which can reduce its emissions by 6 measures. It makes sense to take measure 1 first, then measure 2, etc. in the order of the abatement costs per kg reduced emission (the cheapest measure first). Measure 6 does not make sense, since the abatement costs of that measure are higher than the eco-costs, which means that such a measure is too expensive relative to the sustainability norm in the society. From a macro-economic point of view such a measure is destruction of capital, since the money can be used more efficiently elsewhere.

The "level playing field" for companies is the marginal prevention costs of governmental regulations, with are required at t_1 and t_2. The company must have taken measures 1, 2 and 3 before t_1, otherwise it is fined by the government. The same applies to measure 4 and 5 and t_2.

When the company is delivering its products to a client in the supply chain (e.g. a big retailer or a company in the apparel industry), this client may ask for earlier actions at t_x and t_y. This is likely in the case that the client sells products which are marketed as extra 'green'.

Long lead times of measurements might lead to the situation that the company is forced to take expensive measures first. In the example of Fig. 9.5: when measure 3 has a long lead time, the company might be forced to take measure 4 first, which gives an unfavourable competitive position relative to companies which were pro-active enough in the past to have measure 3 implemented in time.

The conclusion is that sustainability is a key issue in corporate strategy, where timing and long term planning is crucial for success. An important issue is that the required changes are not only internal, but relate to the total product chain: the suppliers of materials and sub-components, the core processes, the use phase and the end-of-life phase, including re-use and recycling, see Fig. 9.4.

9.4 Supply chain management and recycling

9.4.1 Supply chain management

Eco-efficient value creation is not only a matter of a new product *design*. It is also a matter of *implementing* it in the total product chain, inside, but also outside the production company:

- the new materials and the new product components must be sourced from other manufacturers
- systems for product recycling or re-use must be implemented, likely by outsourcing contracts

For those reasons, the purchasing department has a crucial role in implementing the new ideas of the designer on eco-efficient value creation. This role of the purchasing department is rather new: it requires a shift from the classical costs driven attitude towards a value driven attitude.

Most companies apply the so-called Kraljic Matrix for professional purchasing strategies. The focus is here on the profit impact (= reduction of the costs of supplies) and the supply risk (= reduction of the risk of failing on-time delivery, and quality defects). See Fig. 9.6.

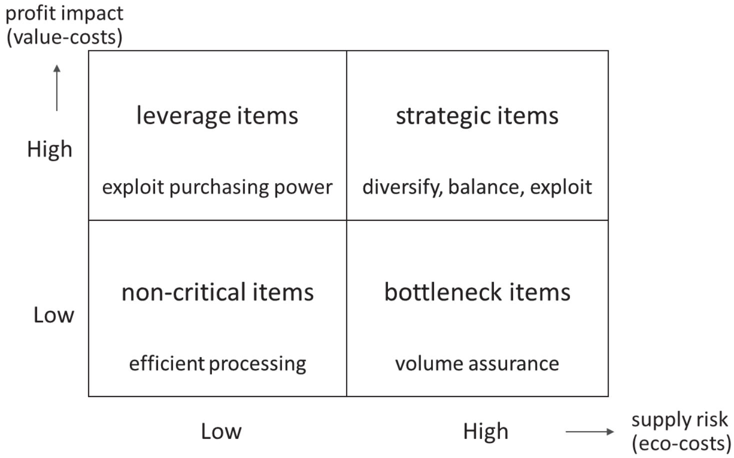


Figure 9.6

The Kraljic matrix for purchasing portfolio management

The Kraljic matrix has four quadrants:

- 'leverage items', where the aim is the lowest purchasing price as possible (the volume is high, products can be purchased from many suppliers)
- 'non-critical items', where the aim is efficient processing (many items with low volumes, which can be purchased everywhere)
- 'bottle-neck items', which have low financial impact (low volume), however, have one, unreliable, supplier per item
- 'strategic items', which have only one supplier which cannot be replaced easily

In the point of view of eco-efficient value creation, the profit impact is not related to the costs only, but is related to 'extra value of the final product' – 'extra costs of materials'. The supply risk is then not only the risk of no delivery, but also the risk of reputational damage, and/or the risk of sudden internalization of eco-costs. Concluding, the eco-costs is on the x-axis and the value is on the y-axis of the Kraljic Matrix.

The Kraljic Matrix is about the selection of suppliers: eco-costs can be used to benchmark suppliers. One step further in strategic purchasing is that a strategic alliance with a supplier is used to bring the eco-costs further down in future, so that the supplier can invest in lowering the eco-costs, as shown in the example of Fig. 9.5 of the previous section.

9.4.2 End-of-life: remanufacturing and recycling (circular economy)

The first design option of end-of-life is re-use of components and remanufacturing (= upgrading the product to a state which is equivalent to new). Remanufacturing was rather common in the past (e.g. for motors in the automotive industry), but became rather exceptional in Western Europe because of high labour costs. Only very robust equipment (e.g. Jungheinrich forklifttrucks) or sports car engines (e.g. Porsche) are remanufactured.
The issue is that it is complex because of the diversity of discarded products, so that these products cannot be handled by modern automatic equipment of mass production, and it is not logical to start a remanufacturing business in the same company.
It is replaced by 'repair + export' to the developing countries, where the repair is often outsourced or done in the developing countries. Although this practice has some unethical aspects, as such it is better for sustainability than discarding the products.

The second design option of end-of-life is the so-called closed-loop recycling [2]. In LCA this brings down the eco-costs of the product life cycle considerably. Many companies are reluctant to implement this solution, since they are afraid of the extra costs incurred. That is the reason that the EU is preparing regulations for obligatory take-back systems in several sectors of industry (e.g. the WEEE take-back legislation in the electronics industry).
Proactive companies, however, have already begun with such systems (e.g. for Nespresso aluminium coffee cups, and Xerox copy machines). Fact is that with 'reverse logistics' the extra costs of the take-back operations are rather marginal (the extra costs are only the handling costs), so it is a matter of modern logistics.
Another solution to reduce the costs of closed loop recycling is cooperation of all companies in one sector in a country (e.g. PET bottles in Switzerland, plastic bottles in the UK, PVC pipes in the European building industry, the take-back system for household appliances in the Netherlands). The introduction of these systems is always slow, however, since there are many companies involved.

A complicating factor for multinational companies is that the end-of-life systems are different for each individual country. In countries like Germany and the Netherlands, combustion of bio-plastics and wood is attractive, since there is a good infrastructure of waste incineration with heat recovery (electricity production): nearly all waste ends up in this infrastructure. In countries like the USA, nearly all waste ends up in landfill, which is a big disadvantage for these materials in terms of eco-costs.

The conclusion is that the favourite end-of-life options in design haven't been implemented yet in society: infrastructure is only available in some regions of the world, and cost-effective business solutions have still to be developed for the majority of cases. This is an area where strict governmental regulations are needed to push the industry forward in a circular economy.

Appendices

Appendix I

The model of the Eco-costs 2012, and 4 operational databases

(source Wikipedia)

General

Eco-costs are a measure to express the amount of environmental burden of a product on the basis of prevention of that burden. They are the costs which should be made to reduce the environmental pollution and materials depletion in our world to a level which is in line with the carrying capacity of our earth.

For example: for each 1000 kg CO_2 emission, one should invest € 135,- in offshore windmill parks (and the other CO_2 reduction systems at that price or less). When this is done consequently, the total CO_2 emissions in the world will be reduced by 65% compared to the emissions in 2008. As a result global warming will stabilise. In short: "the eco-costs of 1000kg CO_2 are € 135,-".

Similar calculations can be made on the environmental burden of acidification, eutrification, summer smog, fine dust, eco-toxicity, and the use of metals, rare earth, fossil fuels and land (nature). As such, the eco-costs are virtual costs, since they are not yet integrated in the real life costs of current production chains (Life Cycle Costs). The eco-costs should be regarded as hidden obligations.

The eco-costs of a product are the sum of all eco-costs of emissions and use of materials and energy during the life cycle "from cradle to cradle". The widely accepted method to make such a calculation is called Life Cycle Assessment (LCA), which is basically a mass and energy balance, defined in the 14040 and ISO 14044.

The practical use of eco-costs is to compare the sustainability of several product types with the same functionality. The advantage of eco-costs is that they are expressed in a standardized monetary value (€) which appears to be easily understood 'by instinct'. Also the calculation is transparent and relatively easy, compared to damage based models which have the disadvantage of extremely complex calculations with subjective weighting of the various aspects contributing to the overall environmental burden.

The system of eco-costs is part of the bigger model of the EVR.

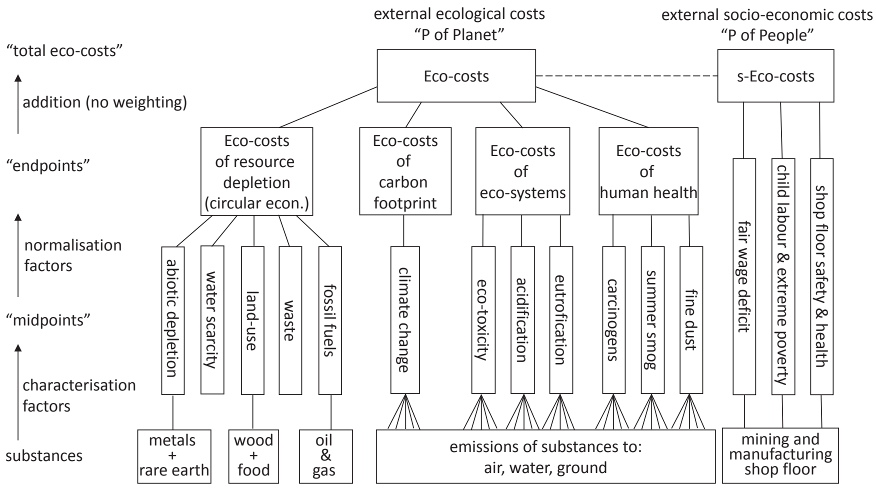
Background

The eco-costs system has been introduced in 1999 on conferences, and published in 2000-2004 in the International Journal of LCA, and in the Journal of Cleaner Production. In 2007 the system has been updated, and published in 2010. It is planned

to update the system every 5 years to incorporate the latest developments in science. In the summer of 2012 a new update has been released.
The concept of eco-costs has been made operational with general databases, and is described at www.ecocostsvalue.com of the Delft University of Technology. The method of the eco-costs is based on the sum of the marginal prevention costs (end of pipe as well as system integrated) for toxic emissions related to human health as well as ecosystems, emissions that cause global warming, and resource depletion (metals, rare earth, fossil fuels, water, and land-use). For a visual display of the system see Fig. A1.

Figure A1

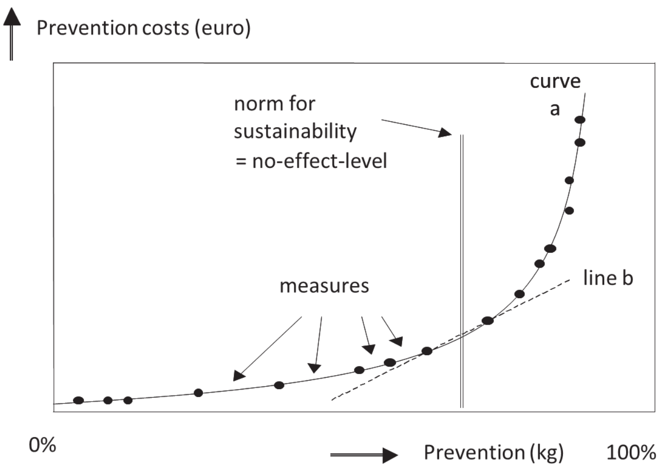
The calculation structure of the eco-costs.



Marginal prevention costs of toxic emissions are derived from the so called prevention curve as depicted in Fig. A2.

Figure A2

Eco-costs are based on marginal prevention costs at the no-effect-level (the costs in euro/kg of the technical measure)



The basic idea behind such a curve is that a country (or a group of countries, such as the European Union), must take prevention measures to reduce toxic emissions (more than one measure is required to reach the target). From the point of view of the economy, the cheapest measures (in terms of euro/kg) are taken first. At a certain point at the curve, the reduction of the emissions is sufficient to bring the concentration of the pollution below the so called no-effect-level.

The no-effect-level of CO_2 emissions is the level that the emissions and the natural absorption of the earth are in equilibrium again at a maximum temperature rise of 2 ^{0}C. The no-effect-level of toxic emission is the level where the concentration in nature is below the toxicity threshold (most natural toxic substances have a toxicity threshold, below which they might even have a beneficial effect), or below the background level. For Human toxicity the 'no observable adverse effect level' is used. The eco-costs are the marginal prevention costs of the last measure of the prevention curve to reach the no-effect-level. See [1] and [4] for a full description of the calculation method (note that in the calculation 'classes' of emissions with the same 'midpoint' are combined, as explained below).

The classical way to calculate a 'single indicator' in LCA is based on the damage of the emissions. Pollutants are grouped in 'classes', multiplied by a 'characterisation' factor to account for their relative importance within a class, and totalized to the level of their 'midpoint' effect (e.g. global warming, acidification, nutrification). The classical problem is then to determine the relative importance of each midpoint effect. This is done by 'normalisation' (= comparison with the pollution in a country or a region) and 'weighting' (= giving each midpoint a weight, to take the relative importance into account) by an expert panel.
The calculation of the eco-costs is based on classification and characterisation tables as well (combining tables from IPCC, the UseTox model, tables of ReCiPe, the ILDC and RiskPoll), however has a different approach to the normalisation and weighting steps. Normalisation is done by calculating the marginal prevention costs for a region (i.e. the European Union), as described above. The weighting step is not required in the eco-costs system, since the total result is the sum of the eco-costs of all midpoints. The advantage of such a calculation is that the marginal prevention costs are related to the costs of the most expensive Best Available Technology which is required to meet the target, and the corresponding level of future Tradable Emission Rights. Example: For reduction of CO_2 emissions to a sustainable level, the marginal prevention costs are the costs of replacement of coal-fired power plants by windmill parks at the sea.
The eco-costs have been calculated for the situation in the European Union. It might be argued that the eco-costs are also an indication of the marginal prevention costs for other parts of the globe, under the condition of a level playing field for production companies.

Eco-costs 2012

The method of the eco-costs 2012 (version 2.00 and 3.00) comprises tables of over 3000 emissions, and has been made operational by special database for Simapro, based on LCIs from Ecoinvent V3, Idemat 2014, and Agri Footprint, (over 10.000 materials and processes), and a database for CES (Cambridge Engineering Selector). Excel look-up tables are provided at www.ecocostsvalue.com.

For emissions of toxic substances, the following set of multipliers is used in the eco-costs 2012 system:

- prevention of acidification 8.25 €/kg SOx equivalent
- prevention of eutrophication 3.90 €/kg phosphate equivalent
- prevention of ecotoxicity 55 €/kg Zn equivalent
- prevention of carcinogens 36 €/kg Benzo(a)pyrene equivalent
- prevention of summer smog (respiratory diseases) 9.70 €/kg C_2H_4 equivalent
- prevention of fine dust 34 €/kg fine dust PM2.5
- prevention of global warming (GWP 100) 0.135 €/kg CO_2 equivalent

The characterisation ('midpoint') tables which are applied in the eco-costs 2012 system, are recommended by the ILCD:

- IPPC 2013, 100 years, for greenhouse gasses
- USETOX, for human toxicity (carcinogens), and ecotoxicity
- RECIPE, for eutrification, and photochemical oxidant formation (summer smog)
- ILCD, for acidification
- RiskPoll, for fine dust

In addition to abovementioned eco-costs for emissions, there is a set of eco-costs to characterize the 'midpoints' of resource depletion:

- eco-costs of abiotic depletion (metals, including rare earth, and fossil fuels)
- eco-costs of land-use change (based on loss of biodiversity, e.g. used for eco-costs of tropical hardwood)
- eco-costs of water (based on the midpoint Water Stress Indicator - WSI - of countries, published by A-M. Boulay, Univ. of Montréal)
- eco-costs of landfill

The abovementioned marginal prevention costs at midpoint level can be combined to 'endpoints' in three groups, plus global warming as a separate group:

eco-costs of human health	= the sum of carcinogens, summer smog, fine dust
eco-costs of ecosystems	= the sum of acidification, eutrophication, ecotoxicity
eco-costs of resource depletion	= the sum of abiotic depletion, land-use, water, and land-fill
eco-costs of global warming	= the sum of CO_2 and other greenhouse gases (the GWP 100 table)
total eco-costs	= the sum of human health, ecosystems, resource depletion and global warming

Since the endpoints have the same monetary unit (e.g. euro, dollar), they are added up to the total eco-costs without applying a 'subjective' weighting system. This is an advantage of the eco-costs system (see also ISO 14044 section 4.4.3.4 and 4.4.5). So called 'double counting' (ISO 14044 section 4.4.2.2.3) is avoided in the eco-costs system.

The eco-costs of global warming (also called eco-costs of carbon footprint) can be used as an indicator for the carbon footprint. The eco-costs of resource depletion can be regarded as an indicator for 'circularity' in the theory of the circular economy. However, it is advised to include human toxicity and eco-toxicity, and include the eco-costs of global warming in the calculations on the circular economy as well. The eco-costs of global warming are required to reveal the difference between fossil-based products and bio-based products, since biogenic CO_2 is not counted in LCA (biogenic CO_2 is part of the natural recycle loop in the biosphere). Therefore, total eco-costs can be regarded as a robust indicator for cradle-to-cradle calculations in LCA for products and services in the theory of the circular economy. Since the economic viability of a business model is also an important aspect of the circular economy, the added value of a product-service system should be part of the analysis. This requires the two dimensional approach of the EVR as described in this book.

The Delft University of Technology is working on a version 3.00 of the eco-costs 2012. In this version, metrics on social aspects of the production chain will be added. Aspects are the low minimum wages in developing countries (the "wage deficit"), the aspect of "child labour and extreme poverty", and the aspect of "OSH (Occupational Safety and Health)".

Prevention costs versus damage costs

Prevention measures will decrease the costs of the damage, related to environmental pollution (e.g. damage costs related to human health problems in terms of DALYs). The savings which are a result of the prevention measures are of the same order of magnitude as the costs of prevention. So the total effect of prevention measures on our society is that it results in a better environment at virtually no extra costs, since costs of prevention and costs of savings will level out.

Discussion

There are many “single indicators” for LCA. Basically they fall in three categories:

- single issue
- damage based
- prevention based

The best known “single issue” indicator is the carbon footprint: the total emissions of kg CO_2, or kg CO_2 *equivalent* (taking methane and some other greenhouse gasses into account as well). The advantage of a single issue indicator is that its calculation is simple and transparent, without any complex assumptions. It is easy as well to communicate to the public. The disadvantage is that is ignores the problems caused by other pollutants and it is not suitable for cradle to cradle calculations (because materials depletion is not taken into account).

The most common single indicators are damage based. This stems from the period of the 1990ies, when LCA was developed to make people aware of the damage of production and consumption. The advantage of damage based single indicators is, that they make people aware of the fact that they should consume less, and make companies aware that they should produce cleaner. The disadvantage is that these damage based systems are very complex, not transparent for others than who make the computer calculations, need many assumptions, and suffer from the subjective weighting procedure at the end. Communication of the result is not easy, since the result is expressed in "points" (attempts to express the results in money were never very successful, because of methodological flaws).

Prevention based indicators, like the system of the eco-costs, are relatively new. The advantage, in comparison to the damage based systems, is that the calculations are relatively easy and transparent, and that the results can be explained in terms of money and in measures to be taken. The system is focused on the decision taking processes of architects, business people, designers and engineers. The disadvantage is that the system is not focused on the fact that people should consume less.

The eco-costs method is not the only prevention based indicator system. The eco-costs are calculated for the situation of the European Union, but are applicable worldwide under the assumption of a level playing field for business, and under the precautionary principle. There are two other prevention based systems, developed after the introduction of the eco-costs, which are based on the local circumstances of a specific country:

- In the Netherlands, 'shadow prices' have been developed in 2004 by TNO/MEP on basis of a local prevention curve: it are the costs of the most expensive prevention measure required by the Dutch government for each midpoint. It is obvious that such costs are relevant for the local companies, but such a shadow price system doesn't have any meaning outside the Netherlands, since it is not based on the no-effect-level.
- In Japan, a group of universities have developed a set of data for maximum abatement costs (MAC, similar to the midpoint multipliers of the eco-costs as given in the previous section), for the Japanese conditions. The development of the MAC method started in 2002 and has been published in 2005. The so-called avoidable abatement cost (AAC) in this method is comparable to the eco-costs.

Four operational databases

In line with the policy of the Delft University of Technology to bring LCA calculations within reach of everybody, open access databases are made available.

To support the Fast Track LCA calculations of this Guide, Excel tables are available on the internet. These Excel tables contain the eco-costs data only (the total as well as the midpoints), since the underlying LCI data are protected with copyright (of Ecoinvent).

Experts on LCA who want to use the eco-costs as a single indicator, can download the full database for Simapro (the Eco-costs Method as well as the Idemat LCIs), free of charge, provided that they have licences for the Simapro software and for Ecoinvent LCIs.

Engineers, designers and architects can have databases, free of charge, for CES and ArchiCAD software, provided that they have the licence for the software.

So, the following databases are available:

- Excel tables on the website www.ecocostsvalue.com, tab 'data' (for designers, engineers, architects, business managers, and students, to be used for the Fast Track LCA calculations of this guide):
  - a table with data on emissions and materials depletion (more than 3000 substances)
  - a table on products and processes, based on Ecoinvent LCIs and Idemat LCIs[41] (more than 5000 lines)
- an import Simapro database for the method and an import database for Idemat LCIs (software for LCA specialists, only available for Ecoinvent licence holders)
- a database for Cambridge Engineering Selector, Level 2 (software for designers and engineers, available via www.grantadesign.com)
- a dataset for ArchiCAD (3D-BIM software for architects, available via www.kubusinfo.nl)

References

For references see:

- [4]
- www.ecocostsvalue.com
- the references given in http://en.wikipedia.org/wiki/Eco-costs

[41] The Idemat LCIs are based the Ecoinvent LCIs. The reasons to make this extra set of LCIs were:

- extra LCIs of alloys (frequently used by designers and engineers)
- a correction of the "market mix" data of metals (Ecoinvent data are outdated)
- extra LCIs of wood types (softwood types as well as hardwood types)
- a specific selection of LCIs for electricity, heat and transport
- extra LCIs of end-of-life (combustion, waste incineration, recycling)
- the Danish food LCIs based on Ecoinvent (instead of ETH data)
- eliminate double counting (of CO_2 and fossil fuels) of electricity in eco-costs

Appendix II

Fast Track LCA for calculation of the eco-burden in the design stage

Introduction
A business manager or product designer is not so much interested in all the ins and outs of LCA: they just want to have quantitative guidance in the decisions they have to take. They don't want to spend much time on LCA, since their primary task is the introduction of innovative products and services. They often have no dedicated computer software, no licenses on LCI databases, and no budget available for specialized LCA consultant firms. They want to do (or at least: understand) it themselves, but the time they can spend on the issue is limited. They are not interested in all the complex theories: they just are interested in results.

Unfortunately, the descriptions on how to do an LCA in the classical way are still mixtures of complex practical guidance and theoretical deliberations. When we have to calculate the price of a house, do we have to know then the theory of Activity Based Costing and the Price Formation Theory? No, we just add-up all the costs.

The basic idea of Fast Track LCA is that environmental burden is added up in the same way it is done in cost calculations, applying look-up tables with "single indicator" data. This reduces the complexity of the LCA enormously, while it is still in compliance with the ISO 14040 and 14044, as well as the formal LCA manual of the ILCD of the EU (ILCD, 2010). It is not less accurate than working with Simapro, since Simapro calculations are the basis.
The basic difference with the classical LCA is that, when the single indicator is selected in the Goal and Scope phase (according to ISO 14044), the complex step of the Life Cycle Impact Analysis as well as the computerised addition of Life Cycle Inventories can be avoided.
The look-up tables are calculated in the formal way, by Simapro, for the most current indicators, and for all available products and processes in Ecoinvent and Idemat (Idemat is an extension of Ecoinvent). These Excel tables are open access on the internet (www.ecocostsvalue.com, tab data), and form the bases of an LCA metrics as described in the book [2]. In this book, some practical choices in LCA are proposed to enable cradle-to-cradle calculations in an unambiguous way.
Note that "Fast Track" must not be confused with "Streamlined" LCA.

Some issues with regards to LCA:

- An LCA of one product does not make sense: it should always be a comparison of two or more products (or a redesign of a product, where you compare the old with the new design).
- The simplest situation is that the products to be compared have exactly the same functionality and quality. In practice, however, different design solutions differ in terms of quality (in the broad sense of the word). Then the EVR approach of this book is needed. Note that this complication is not specific to LCA, since you

would have a similar situation in a cost comparison, where everybody is aware of the "value for money" and the quality/costs ratio.

- Be aware that the accuracy of an LCA is not high: differences of less than 30% are in most cases not relevant.
  Note that this is similar to calculations on costs: data from general databases are often not more accurate than 25%.
- There are several types of LCA:
  "from cradle to gate" (i.e. from the mines to the gate at a warehouse)
  "from gate to gate" (to calculate the eco-burden of a manufacturing facility)
  "from gate to grave" (to calculate end-of-life scenarios)
  "from cradle to grave" (to calculate the total eco-burden of a product system from mine to end-of-life)
  "from cradle to cradle" (closing the loop in the total product system)
  Note that this is similar to "Product Costs", "Production costs", "Recycling costs", and respectively Life Cycle Costs (or Whole Life Costs).
  In most databases with LCI and LCA information, the data on materials are from cradle-to-gate of the factory (in Idemat including transport to the Rotterdam harbour area), as well as data on processing are gate-to-gate.

When you make a cost calculation, you must choose the currency (€, $, £, etc.). When you make an LCA you must select the "single indicator".
At Delft University of Technology you have to choose between 3 types of indicators:

- a 'damage based' indicator: the ReCiPe indicator 'Europe H/A' (unit = Points)
- a 'single issue' indicator: the carbon footprint (unit = kg CO_2 equivalent), or CED[42]
- a 'prevention based' indicator: the eco-costs (unit = €), see Appendix I

Three remarks on the single indicators:

- The carbon footprint has some disadvantages in cradle-to-cradle (recycling) analysis, since materials depletion is not incorporated in the indicator.
- The ReCiPe indicator has the disadvantage of a very high uncertainty for toxic emissions (many calculation steps with many assumptions).
- The eco-costs give the most satisfactory results for wood, end-of-life and C2C calculations.

Since the actual calculation is a matter of a copy/paste activity, you might consider making your LCA in all the 3 single indicators, and finding out to what extend the conclusion is influenced by the choice of the indicator system.

[42] CED seems neither suitable in cradle-to-cradle (recycling) analyses, nor for wood and bio-products when the waste is burned. The main reason is that the CED method has a complex, counterintuitive, approach to distinguish between biogenic CO2 and fossil CO2 and to cope with materials depletion, which are important issues in circular systems. It is suitable for cradle-to-gate calculations of incombustible materials.

Methods for making LCAs

a. Spread sheets in Excel

It is advised to do everything in Excel, just as you do when you make a cost comparison.

You start your LCA with a table (see for a simple example Table A1):

- step 1 make a list of important elements (materials, electricity, transport, waste treatment, et cetera)
- step 2 add the single indicator factor (from Excel look-up tables or LCA software)
- step 3 multiply and add up to the total score

For step 2 you will need the Excel table on products and services at the ecocostsvalue.com website, tab 'data'. There are two datasets: Ecoinvent and Idemat. It is strongly advised to look first in the Idemat list. When something is not available there, look in Ecoinvent.

It is advised to apply the framework of Table A2, since you can see in the table which line of Idemat or Ecoinvent you use.

Note: To speed-up the selection of materials, a book with LCA data is available [3]

Table A1

Example of a simplified LCA calculation table

step 1				step 2		step 3	
	amount			factor		score	
materials	steel	0,8	kg	0,49	€/kg	0,392	€
	polypropylene	0,3	kg	1,02	€/kg	0,306	€
production	electroplating chrome	0,2	m2	2,28	€/m2	0,456	€
transport	sea container	21	tonkm	0,0052	€/tonkm	0,109	€
use phase	electricity	3,6	kWh	0,109	€/kWh	0,392	€
end-of-life	land fill	1,1	kg	0,118	€/kg	0,13	€
	Total					1,785	€

b. LCA Software Tools for EcoDesign

Examples of LCA software tools for product design:

- The Eco audit tool in CES Edupack of Granta-design.
  This is a typical quick-and-dirty tool for designers, only to be used in the beginning ('fussy front end') of the design. The available types of materials are limited, but the material characteristics can be found in the same database as well. Eco audit of CES Edupack is only suitable for simple end-of-life situations.
- The LCA tool at the website www.design-4-sustainability.com.
  This tool has more LCA data and enables more complex LCA calculations (allows for simple as well as more complex calculations).
- Simapro or Gabi, tools for experts who want to make their own Life Cycle Inventories or who want to have additional info on the Idemat or Ecoinvent data

A Step by Step procedure

- **Step 1 Establish the scope and the goal of your analysis (this step might be done <u>after</u> step 2 in the case that it is a <u>total new design</u>)**
    - is it a comparison of two or more products?
    - is it an attempt to improve the environmental characteristics of a typical design?
        - less, or less harmful, materials?
        - less energy in the use phase?
        - less transport?
        - better recycling or better incineration of waste for electricity?
        - cradle-to-cradle solution?
        - better durability?
- **Step 2 Establish the System, Functional Unit and System Boundaries**
    - Describe the function of your product or service:
        - example for a coffee machine: 1000 cups of coffee per year (or: … cups over the life time)
        - example for a transport system: 50 m^3 freight over a distance of 300 km, no payload back
    - Make a drawing of your product system (from cradle-to-grave, or from cradle-to cradle). See Fig. A3.
    - Determine the life time of the system components.
    - Establish one or more transport scenarios (e.g. bamboo from China or Latin America).
    - Establish the system boundaries (what do you include and what do you neglect in your system?).

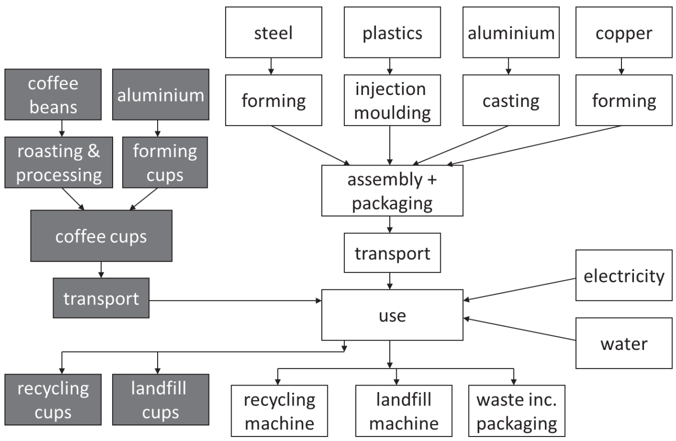


Figure A3

A "process tree" in LCA of a coffee machine

- **Step 3 Quantify materials, use of energy, etc. in your system**
    - Collect (measure) data (e.g. weight, material, energy consumption).

  - Determine accuracy and relevance; establish allocation rules (or scenarios) and cut-off criteria.
- **Step 4 Enter the data into an Excel calculation sheet or a computer program**
  If an indicator value for a material or process is missing in the look-up table, this can be resolved as follows:
  - check whether the missing material or process could make a significant contribution to the total environmental impact, if not, neglect it (if it is expected under the cut-off criterion)
  - substitute a known process for the unknown one which has the same characteristics (take a surrogate process). For example: If you miss an indicator value for a certain type of plastics, find out which known plastic is similar
  - search in EPD database (e.g. of Germany or France) and apply [2, Appendix VI]
  - take the required energy for the process, calculate the eco-burden of it, and add the eco-costs of the extreme toxic emissions (if any); see for the eco-costs of emissions www.ecocostsvalue.com, tab 'data'
- **Step 5 Interpret the results and draw your conclusions**
  When you have entered everything in your computer program or calculation sheet, you can add up the total eco-costs of your product (and/or service). However, it is not the aim of an LCA to have the total eco-costs only. The aim of LCA is always a comparison with other products and/or alternative designs or processes. So, the last step of LCA is an analysis of the total output, including relevant details.
  Note: it might be that you conclude in this last step that you have to (partly) redo your calculation, since elements are missing or are not accurate enough

list of materials			eco-costs data		result	total	
PRODUCTION			copy paste from 'Ecocosts 2007 LCA data on products and services V2-2, 2010'				
type	*weight (kg)*	*process step*	*LCI name in Idemat, Ecoinvent or CES*	*eco-costs (€)*	*eco-costs (€)*	*eco-costs (€)*	
PS=polystyrene	y1	production	Idemat2010 PS (HIPS)	1.338	=C5*F5		
	y1	moulding	Idemat2010 Injection moulding	0.257	=C6*F6		**text for gr**
						=G5+G6	polystyren
aluminium	y2	production	Idemat2010 Aluminium trade mix (65% prim 35% sec)	2.748	=C8*F8		
	y2	extrusion	Cold impact extrusion, aluminium, 3 strokes/RER S	0.307	=C9*F9		
						=G8+G9	aluminium
sheet steel	y3	production	Idemat2010 Steel (21% sec = market mix average)	0.494	=C11*F11		
	y3	forming	Deep drawing, steel, 10000 kN press, single stroke operation/RER	0.086	=C12*F12		
						=G11+G12	steel
glas	y4	production	silica glass from CES (very resistant to temperature shocks)	0.300	=C14*F14		
	y4	forming	silica glass from CES (very resistant to temperature shocks)	0.22	=C15*F15		
						=G14+G15	glass
plus other small components, such as the heating coil (copper from Idemat), electrical cable (Idemat), and packaging (board from Idemat)							
TRANSPORT							
from-to	*m3*	*km*					
Shanhai-R'dam	z1	x1	Container ship TUI2006, 40 ft con (from tab 'general industry')	0.0044	=C20*D20*F20		
plus other transport legs						=G20	transport
USE PHASE							
type	*weight (kg)*	*energy (kWh)*					
electricity	-	e1	Idemat2010 Electricity Low Voltage, domestic use (UCTE)	0.030	=D24*F24	=G24	electricity
plus materials which are used in the use phase (in this case cofee, packaging, water						=G25	materials
END of LIFE							
type	*weight (kg)*	*process step*					
PS	y1	municipal waste	Idemat2010 Polystyrene (PS) waste incineration with electricity	0.273	=C28*F28		
						=G28	EoL PS
aluminium	part of y2	landfill	Idemat2010 landfill	0.118	=C30*F30		
aluminium	part of y2	to recycling	Idemat2010 Scrap (alum.)	0.049	=C31*F31		
						=G30+G31	EoL alumir
sheet steel	part of y3	landfill	Idemat2010 landfill	0.118	=C33*F33		
sheet steel	part of y3	to recycling	Idemat2010 Scrap (iron)	0.010	=C34*F34		
						=G33+G34	EoL steel
glas	y4	landfill	Idemat2010 landfill	0.118	=C36*F36		
plus the materials of the use phase						=G36	EoL glass
				Total eco-costs (€)		=SUM(H7:H37)	

Table A2

An Excel spread sheet that can be downloaded from the ecocostsvalue website to serve as an LCA calculation template

Appendix III

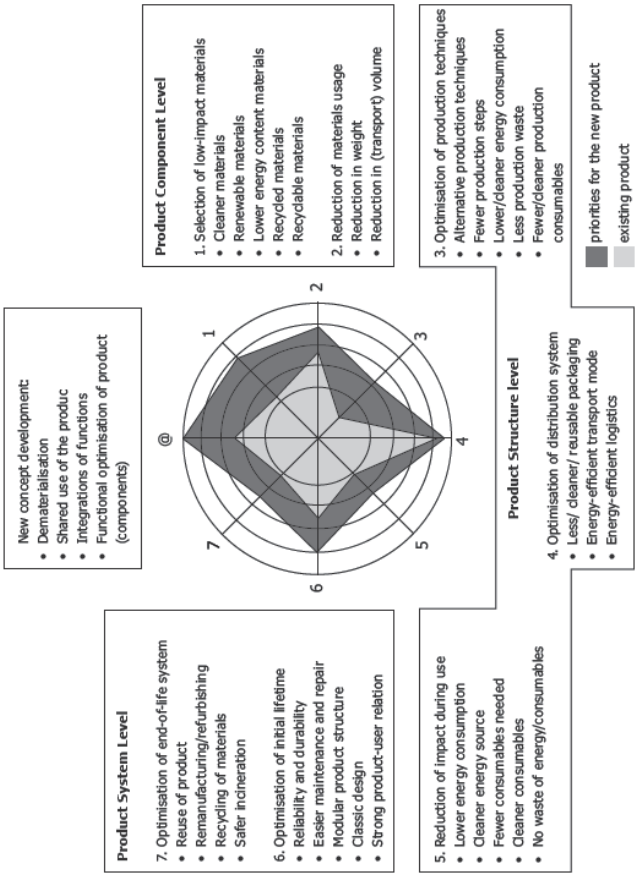
Benchmarking products with different quality and/or functionality

Life Cycle Assessment (LCA) is the generally accepted method to compare two (or more) alternative products or services. A prerequisite for such a comparison is that the functionality ('functional unit') and the quality of the alternatives are the same (you cannot compare apples and oranges in the classical LCA). In cases of product design and architecture, however, this prerequisite seems to be a fundamental flaw in the application of LCA: the designer or architect is aiming at a better quality (in the broad sense of the word: including intangible aspects like beauty and image), so the new design never has the same quality. In some cases the functionality of the design is not the same, since the design solution is limited by a maximum budget, in some cases the functionality is the same, but the higher quality results in a higher price. In all these cases a single indicator in LCA (like the eco-costs) is not suitable for environmental benchmarking. In these cases however, it does make sense to compare the design alternatives on the basis of the eco-costs/value ratio (EVR), where the value is the perceived customer value (the WTP, the fair price). See Section 2 on the EVR and decoupling.

Example 1. Different types of armchairs differ in terms of comfort, aesthetics, etc. rather than in terms of functionality. A classical LCA (with a single indicator like eco-costs, carbon footprint, etc.) does not make sense here. Selection on the basis of EVR, however, is the key to a sustainable consumption pattern. The chair with the lowest EVR is the best solution in terms of sustainability. For a design method, see Section 4.

Example 2. In LCA, the comparison of a new building and a renovated building is in the majority of cases not possible, since, in practice, both solutions differ in almost all quality aspects (tangible as well as intangible). However, the solution with lowest EVR is the best in terms of sustainability.
Note that the renovated building is the best solution in most of the cases, because it has the lowest EVR in the production phase. However, in some cases the renovated building is not the best solution, because of unfavourable energy consumption (high EVR) in the use phase.

Appendix IV



The LIDs wheel: checklist for environmental product improvement

Source: Brezet, H. and Hemel, van, C. (1997) EcoDesign: A Promising Approach to Sustainable Production and Consumption, UNEP, France.

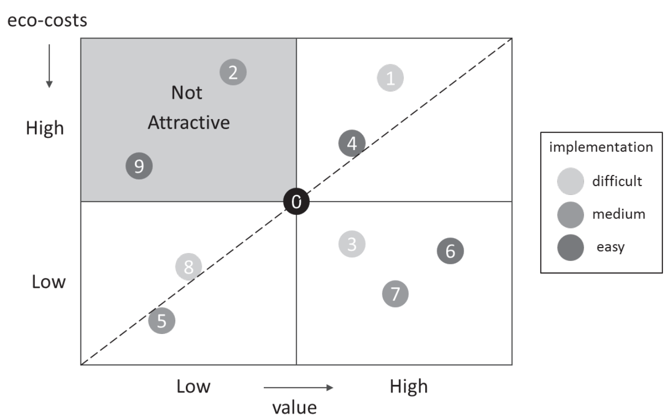
Appendix V

The EVR Decision Matrix for selection of design alternatives

The product portfolio decision matrix in this book, based on the EVR, provides a good basis for selection of design alternatives. However, it is presented in this book as a careful analysis, requiring a lot of work to gather the data on eco-costs (by LCA) and value (by Willingness To Pay enquiries).
This Appendix presents a quick-and-dirty decision tool to select the most promising sustainable solution from a number of design alternatives in the fuzzy front end of the design. The basic idea of this design tool is that a design team can sit together and discuss what the most promising design solutions are. The design team can do this in a half-a-day session.
.
The basis of the tool is the product portfolio matrix of Fig. A4. The eco-burden (e.g. eco-costs or carbon footprint) of a product is on the y-axis, the value (Willingness To Pay, WTP) is on the x-axis. The matrix has 4 quadrants: low eco-burden, low value; low eco-burden, high value; high eco-burden, low value; high eco-burden, high value. It is advised to place a reference product (e.g. the existing product to compete with) in the middle.

Figure A4

The EVR Decision Matrix for eco-efficient value creation



The design objective is low eco-burden, high value (e.g. point 3, 6, and 7 in Fig. A4).
The value of each solution is determined by the team members: they decide on the relative position of each solution.
The eco-burden can be based on the guts feel of the team members, but it is better to assess the eco-cost on the basis of the eco-costs of the used materials only (neglecting processing, transport, and the use phase), being the sum of the materials production

and the end-of-life. Either the LCA DATA book [3] or the Excel look-up tables of the Idemat data at www.ecocostsvalue.com can be used.

Each solution has a position in the matrix. Sometimes it is wise to give a further indication of the characteristics of solution by labelling each solution with a colour: red, green, blue (respectively high, medium, low). Such an additional characterisation can be of the estimation of:

- the potential size of the market
- the costs of the product
- the ease of the implementation
- the complexity of (mass) production
- et cetera

When can you use the EVR Decision Matrix in design?

It is recommended to use the EVR Decision Matrix at the beginning of the design (the fuzzy front end of idea generation), especially for the issues of the 'value proposition', recycling (C2C) and materials selection. It is also suitable in the concept development stage, especially to optimise the value of the product, and at the end of the design, when the introduction of the product is discussed (marketing, PSS and sourcing).
It might be considered in other stages of the product development as well, to structure team based decision taking. One might replace the eco-burden at the y-axis by other indicators, such as indicators which are related to the aspects of social responsibility (e.g. the Base of the Pyramid issue).

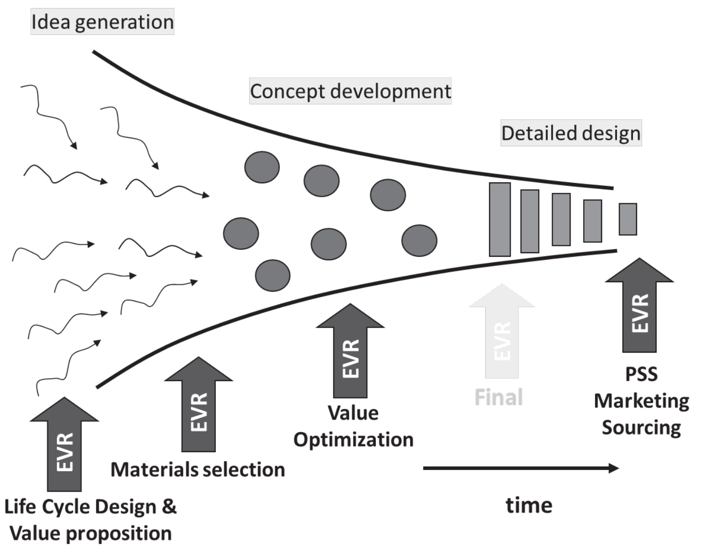


Figure A5

The use of the EVR Decision Matrix during the design process.

Possible procedure for the use of the EVR Decision Matrix

Step 1 Rank the product solutions in order of relative value (WTP).
Use post-its, and glue these post-its along a straight line, according to the relative positions of their (relative) value (be aware that positions can shift during the discussions in the team). Agree on the final result

Step 2 Rank the product solutions in order of relative eco-burden, e.g. relative eco-costs. Do the same as in step 1, now for the eco-burden (eco-costs).
You might do this on the basis of 'guts feel', however, it is wiser to make a quick assessment of the eco-costs on the basis of the expected weight, multiplied by the eco-costs of materials (cradle-to-gate) minus the end-of-life credits. Data can be found in the LCA Data Book [3] or the Excel look-up table on the website www.ecocostsvalue.com, tab 'data'.

Step 3 Characterise the product solutions in terms of an important issue. An issue might be: expected market volume, ease of implementation, ease of production, costs, et cetera.
Give each product solution a red dot for 'high', a green dot for 'medium' and a blue dot for 'low'.

Step 4 Draw the EVR Decision Matrix on a white board or flip over, and draw a red, green or blue dot at the right spot for each product solution (do not forget to label each solution).

Step 5 Discuss the result and decide on the most attractive solutions. Mark the chosen solutions, make a photograph of the matrix, and note down the reasons for the decisions of your team.

Tips and concerns

- Avoid "paralysis by analyses"
- Use multi-voting to select the attractive solutions in a "first round" (give each team member 3 votes; a team member can spread his 3 votes over 3 solutions, can give 2 votes to one solution and 1 vote to another solution, or can give all 3 votes to one solution; the solution with the highest total score wins)

Appendix VI

The Pareto Optimal selection of design solutions

Pareto efficiency is a concept in economics and engineering to select the best options out of a cloud of options. This theory is relevant for concepts with two (or more) dimensions. In the EVR model we have the dimension of eco-costs and the dimension of value. The double objective of the designer is to reduce the eco-costs and enhance the value at the same time, with an existing product as reference, as explained in Section 2, 3, and 4.
Suppose that the designer has more solutions which fulfil this criterion. The question is then which solution is the best.

The first step is to determine the Pareto Front, which are all solutions which are Pareto Optimal. A solution is Pareto Optimal when there is no other solution which fulfils the double objective of having lower eco-costs *and* higher value. See Fig. A6.

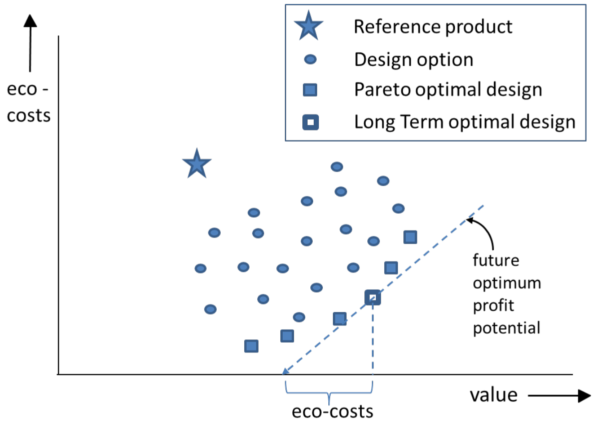


Figure A6

Pareto Optimal design and the best long term solution

The second step is the choice of the best solution in the Pareto Front. In the essence, this is a subjective choice: from the environmental point of view it seems to be the Pareto Optimal solution with the lowest eco-costs (or better: the lowest EVR ratio), however, from the business point of view it seems that the Pareto Optimal solution with the highest value is the best choice. The solution with the highest value, however, is a short term business optimum; because it has still the long term threat of internalising the eco-costs (see Fig. 1.3). For this reason, the long term optimal design for business is a Pareto Optimal solution with the highest score for (value – eco-costs), see Fig. A6. This solution has the highest profit potential in future: it is the long term optimum choice for the company as well as the society.
Note that other criteria, such as social aspects, might influence this choice within the Pareto Front solutions (then, the optimisation problem will have more than 2 dimensions).

Appendix VII

The Circular Transition Framework

In order to deal with the complexity of the design of circular business models and the introduction of it, a Circular Transition Framework has been developed[43]. It describes the different system levels, the stakeholder networks and value creation within these networks, as well as the related effects of regulatory drivers. (See Fig. A7). The Framework describes the product life cycle in four stages: production, marketing, operation and end-of life.

The main stakeholders in the circular business model are represented on four different systems levels:

- The Product-Technology level which refers to tangible products. The use of a product is considered a product-service system, if the ownership of the product resides with other stakeholders than the end-user.
- The Services and Infrastructure level which refers to infrastructure systems and services that are inextricably linked to the products of the product-technology level
- The Regulation and Subsidies level which is related to the contribution of authorities (local, regional and governmental). For the design and implementation of a complex circular business system, it is important to realize that regulations (laws, subsidies, taxation) are often indispensable elements to support and facilitate environmentally sustainable innovations. It is important to consider that regulations on this level are likely to have a broader impact than only on the business model under study.
- The Societal System level which is the highest level in the framework. A circular business model has an interaction with the world around it. There are third parties (stakeholders) who benefit from a business innovation; however, there are also third parties who will feel that their current conventional business is attacked by the new business model. The management of the introduction of a circular business system should analyse these outside forces in order to take the appropriate actions. These outside forces of course also include the environment.

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[43] Arno Scheepens, PhD Thesis to be expected in 2015, available at the Repository of the Delft University of Technology, inspired by the Multi-Level Design Model of Joore in his thesis 2010, available at the same Repository, http://repository.tudelft.nl . This framework has first been introduced in R. Rivas-Hermann, J. Köhler and A. E. Scheepens; Innovation in product and services in the shipping retrofit industry: A case study of ballast water treatment systems. Journal of Cleaner Production 2014

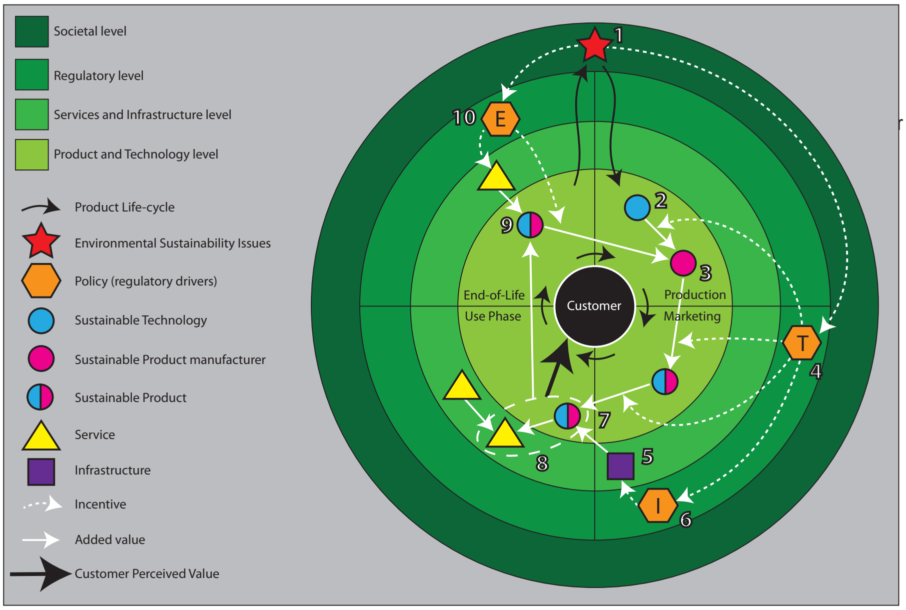


Figure A7.

The Circular Transition Framework for business innovation towards a

economy

The symbols in the framework are explained by a general example.

- The raison d'être of a new circular business model is the desire in society to become more sustainable (star 1)
- Entrepreneurial companies develop new sustainable technologies(circle 2)
- Product manufacturers develop innovative products with the new technologies (circle 3)
- It often appears that the new product cannot be sold without tax reductions (hexagon "T" (4))
- In complex cases infrastructure is needed (e.g. database systems, communication systems, electric grids, see square 5)
- The required infrastructure might be subsidised (hexagon 6)
- The new products are distributed in the consumer market in existing systems (7)
- In the use phase, the product + services might be leased or rented to the consumer (PSS bundle (8)); here, the increased customer perceived value is delivered.
- At the end-of-life the product is returned to the manufacturer (or a specialised recycling company) to be dismantled and recycled (9), closing the loop
- The government might regulate the recycling activity (hexagon 10)
- The society is happy (or not) with the new business system, which affects further governmental support or which triggers new developments (star 11)

Appendix VIII

Domestic energy conservation, the rebound effect and the EVR

In Section 2.4 the issue of the rebound effect is explained. In Fig. 2.8 an example is given on the weight reduction of a car, and its positive effect on eco-costs and the EVR. Fig. 2.9 explains why the positive effect of better aerodynamics of a car is reduced (or even nullified) by the rebound effect. The positive effect of better aerodynamics is not transferred to the environment, but to another benefit for the user: driving faster or driving more.

Three types of rebound effect can be distinguished:

- The *direct* rebound effect ('substitution effect') where the rebound is in the same function (e.g. people who install low-energy light bulbs tend to be less strict on turning off the light when they leave the room, or even install these light bulbs in their gardens)
- The *indirect* rebound effect ('income effect') where the rebound is in another functional area (e.g. people tend to travel more when they save money by energy conservation)
- The *economic wide, long term,* rebound effect (e.g. when cars become more energy efficient, driving becomes cheaper so more people can afford driving, resulting in more cars), so that the rebound can become more than 100% (the Khazzoom-Brookes postulate, claiming that some energy conservation methods can 'backfire')

An excellent comprehensive explanation of the theory of the rebound effect can be found on Wikipedia: http://en.wikipedia.org/wiki/Rebound_effect_(conservation)

The model of the EVR is based on the theory of the *direct* and the *indirect* rebound effect [1, Section 5.7] [4, Section 5.6]. The examples on cars in Section 2.4 are examples of *direct* effects. The emphasis in this Appendix is on the *indirect* effect (the income effect, see Section 2.3 and Fig. 2.6a and 2.6b on consumer behaviour).

Fact is that environmental economists are much less enthusiastic about energy savings than designers, engineers and environmentalists are. The reason is that designers tend to take the product and its use within the system boundaries; however, the economists tend to take a whole family life, or even a country, within the system boundaries.
The EVR model follows the point of view of environmental economists. From that point of view energy conservation is OK, as far as you have to pay money for the conservation measure. Even: the more money the conservation measure costs, the better it is for sustainability.
Fortunately, energy conservation measures cost quite much money (cheap measures have already been implemented in the past). Therefore, nearly all modern measures in Western Europe are good for sustainability. However the effect of a measure should not be exaggerated, which will be explained by means of Fig. A8.

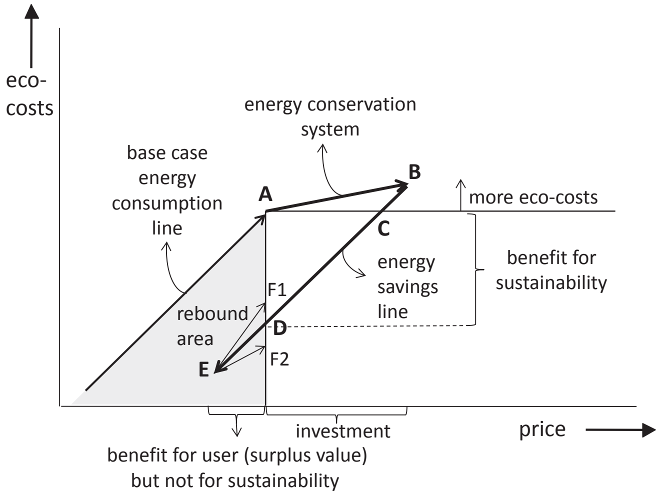


Figure A8

EVR analysis of an energy conservation system

Fig. A7 depicts the EVR analysis of an energy conservation system. The base case is an energy consumption line that ends up in point A. Then an investment is made, and the effect on eco-costs and value (price) is shown by line A-B (this is the 'production phase' in LCA). Note that the EVR of energy is much higher than the EVR of the investment. The 'use phase' of the LCA is the energy saving of line B-E (in parallel to the 'base case energy consumption line'). This line crosses the 'more eco-costs' line at point C (after the 'eco-pay-back time' [4, Section 5.5]), which is likely to happen in practice. Point D is the pay-back point of the investment, with a corresponding reduction of the eco-costs from point A to point D. Then, however the 'energy savings line' enters in the 'rebound area'. From point D to E, the owner is having a benefit (i.e. the owner is saving money, the 'surplus value', see Fig. 5.7). That money, however, is spent on something else: travel, investment in the house, et cetera, which is causing a rebound (line E-F1 for travelling; line E-F2 for renovation or refurbishing a house). The EVR of heating is lower than the EVR of diesel, but higher than the EVR of renovation and refurbishing.

Such a calculation differs for each country, since the (energy) tax level varies from country to country, and the source of the energy may vary as well. The rebound depends also from case to case, but it is safe to assume that the rebound effect is 100% on eco-costs. That means that line D-E is a benefit for the user (the user saves money that will be spent on something that the user prefers), but is not a benefit for the environment. In practice that means that only the first few years (the pay-out period) have a positive impact on the environment, without the rebound effect.

The maximum reduction of eco-costs at point D is:

$$\textit{eco-costs}_{\text{reduction max}} = \textit{(investment)} * EVR_{\text{line A-B}} - \textit{(investment)} * EVR_{\text{line B-D}}$$

Note that the eco-costs in this equation are negative (a reduction of eco-burden).

Appendix IX

The EVR of waste, recycling and re-use of product components

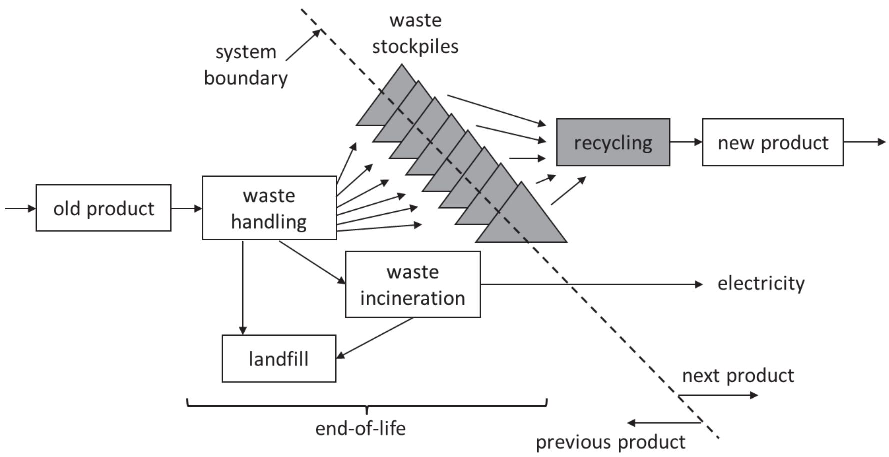
Waste[44] in the product chain

Waste treatment in the product chain is considered as *cost*, not *value* (see Fig. 2.1 and 2.2, Section 2)

The costs of *industrial waste* are part of the costs structure of a product, so it affects the profit margin of a product, but not the value. *Post-consumer waste* is generally not paid for by the consumer, so has also no value either. Therefore, **the (added) value of waste (output of the product chain) is zero with respect to the value of the product**.

Figure A9

Waste treatment in end-of-life



The eco-costs of waste is not zero, see Fig. A9. It is the sum of:

- the eco-costs of transport plus the materials handling
- positive eco-costs for land-fill (for the part of the waste which is landfilled)
- negative eco-costs (a credit in LCA) for combustion with heat recovery and/or for closed loop recycling, see [2, Section 5 and Appendix V]

The dotted line (the system boundary) is also called 'end-of-waste' (e.g. in EN15804).

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[44] Waste in the EVR model is defined in [2, Section 5.1]. Waste is material that goes either to land-fill or waste incineration, or requires waste treatment (sorting, shredding, etc.) and recycling (up- as well as down-cycling). Post-consumer waste stems from products at the end-of-life (the moment the original function of the product stops, and the product is discarded). Production-waste is defined as material (or energy) from the input that is no longer useful or required in the production process, and is discarded. This definition differs from a general definition used in science, where by-products are products with a positive market value, and waste is a product with negative market value. Such a definition, however, is unpractical for designers and engineers, since the market value of waste depends on the time, the place, and the quantity of the waste: some types of waste like waste paper and waste from buildings can have a negative as well as a positive market value.

Recycling and re-use of product components[45], Urban mining

In the circular economy, there is a growing business for recycling, and reuse of discarded product components (remanufacturing). Here, the discarded products and materials are reclaimed ('urban mining') to become the start for new (secondary) materials and products. These activities are a form of value creation.

In LCA and in the EVR method, the recycling activities have to be regarded as part of new products in new product chains, since there is often no direct (predictable) relationship between the old product and the new product (in open loop recycling, see [2, Section 5, Fig. 5.7]). The eco-costs **at** the waste stockpile are zero, just like the eco-costs of ore in the ground **before** mining (Obviously, the 'eco-costs of materials depletion' of recycled materials from urban mining is zero).

The eco-costs of materials derived from waste by urban mining can be easily calculated when the mining and upgrading processes are known, applying the standard LCA rules [2].

It seems to make sense to apply the EVR model to benchmark different products which stem from urban mining: which solution (scenario) is the best for the environment? As it is for 'virgin products', a product with the lowest eco-score is often not the best solution in terms of eco-efficient value creation.

It is the value, however, which makes such an analysis a bit complex. There is often confusion about the value of products and materials in recycling systems. The following parameters are often mixed up[46]:

- Costs of recycling activities
- Value of recycling activities
- Value (market price) of waste, recycled materials, and product components to be re-used

A special aspect of waste is that it can have a positive as well as a negative market price (value), as depicted in Fig. A10.

A positive price (value) of waste is defined as the amount of money you have to pay to acquire the waste. Example: the price of metal scrap (Case 1 in Fig. A10).

A negative price (value) of waste is defined as the amount of money you receive from the owner when you acquire (take away) waste. Such a negative market price is caused by the fact that a landfill levy has to be paid to dump it in a controlled, legitimate, way ('dumping costs'). So the owner has to pay to get rid of the waste. Example: construction and demolition waste (Case 2 in Fig. A10).

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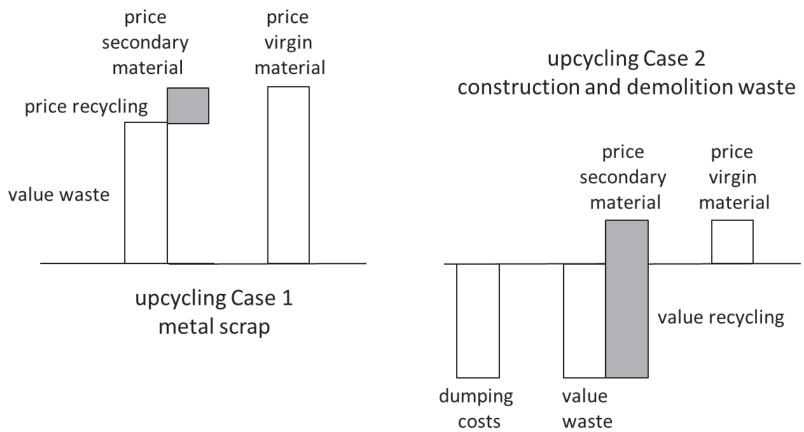
45 Not to be confused with the way second hand products have to be calculated: the use phase has to be taken over the total life time, regardless whether or not there are more than 1 user. For long lasting durable goods see [2, Section 5.6].

46 Theoretical aspects of cradle-to-cradle calculations, the benefit of recycling and the difference between these 3 parameters are described in [1, Section 4].

Case 1: metal scrap. The left hand bar chart in Fig. A10 shows a positive value of waste under the assumption of upcycling (i.e. the recycled material can replace virgin material, since it has the same quality): the price of the recycled material is equal to the price of the virgin material.
This leads to a maximum price of the waste (the value): the value of the waste is equal to the price of the virgin material minus the price of the recycling activity.

Figure A10

The value (market price) of waste can be positive as well as negative. Two cases of upcycling



Case 2: construction and demolition waste. The right hand bar chart of Fig. A10 depicts another situation: a negative value for waste. It is the example of concrete aggregate (crushed concrete). This material can replace gravel in concrete, so gravel is regarded here as the virgin material. The costs of crushing concrete is much higher than the value of the aggregate, however, the recycling process is an alternative for dumping. When the dumping costs (landfill levy) are high, there is a high value of the recycling process (i.e. crushing concrete). At a certain level of dumping costs, the value of crushing is more than its costs. When the dumping costs are too low, the value of crushing is less than its costs, which means that the crushing activity is non-existent in a free market economy. In this example, the government can stimulate recycling by a higher landfill levy.

For an EVR analysis of the "next product" (see Fig. A9) it means that the value of the recycled <u>material</u> must be taken, in combination with the eco-costs of all recycling <u>activities</u> of that material (just like it is done for mining of virgin materials).
The costs of the recycling activities are not relevant for the "next product" in the EVR model, since it is partly compensated by the landfill levy.

A lower grade of metal scrap requires higher upcycling efforts, so a higher recycling price, requiring a higher negative value of the scrap to make the recycling feasible.

A lower grade of the recycled material (the case of downcycling) corresponds with a lower value of it, requiring a higher negative value of the scrap as well.

In the two examples of Fig A.9, the recycled materials are compared to the virgin materials. In general, however, the value of a recycled material is determined by what you can make out of it. In the case of re-use of product components, the recycling processes and the eco-costs of it can be avoided, which is an advantage under the condition that the value of the re-used component is at least at the level of the waste value (which is likely in a free market economy).

Case 3 is the last case of this appendix: the downcycling process of waste paper. See Fig. A11.

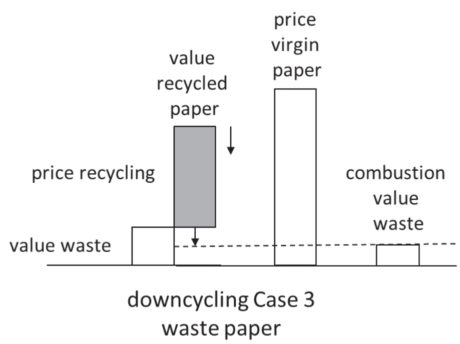


Figure A11

The downcycling process of waste paper

The issue here is that waste paper, just like wood waste, is combustible, so there is a lower limit to its price. The more waste paper is recycled, the shorter the fibres will be, resulting is less value (quality) of the recycled product. After 3 x recycling (4 lifetimes of the paper product), the fibre becomes too short: the remaining value of the waste paper becomes lower than the combustion value of it.
Note: In the waste paper trade business it is common practice to mix lower grades with higher grades, in order to meet the minimum specification set by manufacturers of recycled paper. In this way the trade business optimizes the use of waste paper.

Appendix X

Sustainability paradigms: Egalitarians, Hierarchists, and Individualists

In Section 1.1 sustainable development has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs", referring to the Brundtland report page 43. In the same section, the WBCSD mission statement gives a practical translation of the required sustainable development in terms of the obligation of companies. This book translates this mission statement to the 'double objective' of product design.
The underlying assumption is the mechanism as described in Section 1.3 Fig. 1.4, the 'three stakeholders model', where the interaction between the citizen/consumer, the government and the industry is described. This description is based on the observation what happened in the last 3 decades in Europe.

Although the three stakeholders model can be underpinned by an abundance of data, cause-effect relationships are far from simple in society. Observations in the field of sustainable developments are always subjective, and influenced by the underlying cultural paradigm. The debate on how to implement sustainable development in the (near) future in our society is determined by our personal beliefs, and therefore our cultural paradigms.
This appendix gives a short description of the main paradigms which are relevant for de sustainability debate. These paradigm descriptions stem from the 'Cultural Theory of risk'. See for a short description
http://en.wikipedia.org/wiki/Cultural_Theory_of_risk.

The Cultural Theory is a two dimensional model of cultural ways of life. The two dimensions are:

- 'group', with ' high group' (a way of life with much collaboration between individuals) and ' low group' (a way of life with the emphasis on self-esteem, self-sufficiency and self-development)
- 'grid', with 'high grid' (a society with authority) and ' low grid' (a society with equality)

Such a two dimensional approach leads to 4 cultural paradigms. The paradigms are: individualist, egalitarian, hierarchist, and fatalist. See Fig. A12.

The relevance of this theory on cultural paradigms is that it should be realised that discussions between people of different paradigms are extremely difficult: these people often don't understand each other (they "speak a different language").

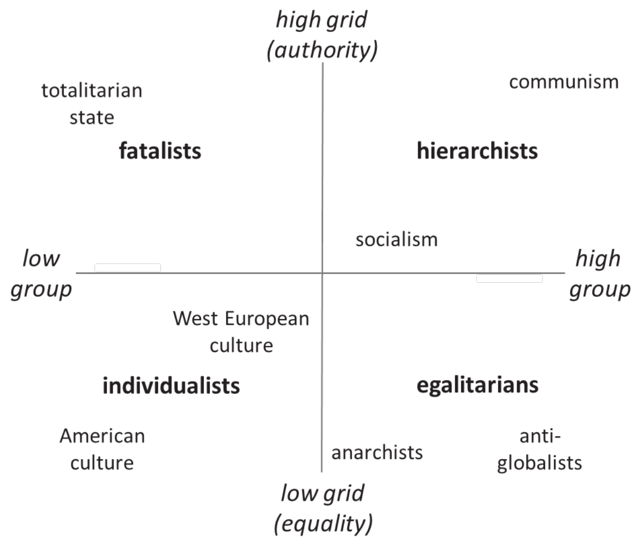


Figure A12

The 4 paradigms of the Cultural Theory of Risk

In the debate on sustainable development, the issue is that the vast majority of business people are individualists, whereas many environmentalists seem to be egalitarians (papers of leading authorities in the field if sustainable design, like Manzini, Vezzoli, Tischner and Ryan are written from the egalitarian point of view), or hierarchists (wanting a top down master plan for sustainability).

To give a more detailed description of the three important paradigms, some key paragraphs are quoted in the text below. These quotations are from Section 2.3.2, 2.3.3, and 2.3.4 of the book of Tukker et al. "System Innovation for sustainability, 1", 2008.

An individualistic view: sustainability through the market
"The individualist has a basically optimistic view of the world and d human nature, and believes that individual ingenuity will in the end bring the solution to problems. Hence, the realisation of sustainable development becomes a matter of channelling individual incentives along the right direction, but leaving a significant degree of freedom for individuals and groups to develop their own, preferred, solutions. The position reflects an entrepreneurial spirit, and often coincides fairly well with the views of organisations representing industry debates. Debates on the question on how to realise sustainability are no exception.
The World Business Council of Sustainable Development (WBCD), probably the most influential think-tank on sustainability, even has a slogan that reflects this: 'Sustainability through the market'……….The idea is that, once perverse subsidies are abolished, and the undesirable side-effects of our current production and consumption systems ate internalised into market prices, market mechanisms will direct innovations along the right, sustainable direction, endorsed by informed consumer choice for sustainable

products. Sustainable development then becomes a matter of time. And, indeed, there are various examples that show the power of market-based instruments in fostering change. Temporary tax measures paved the way for lead-free petrol, and for cars with catalysts, in various countries in the EU, and a tax exemption gave a massive boost to the introduction of 'green' electricity in The Netherlands."

The critique on this paradigm is that the free market is in the USA almost a goal in itself (the paradigm of one of the most influential American economists, Milton Freedman). This critique is right in the eyes of Europeans, who think that the market must be restricted by governmental regulations, to prevent unwanted and unsustainable situations caused by maximisation of profits (Europeans are less extreme individualistic than Americans, see Fig. A12). Another critique is that the modern free market economy stimulates hyper consumption (once you have bought your iphone-4, Apple makes you unhappy with it: you should buy their iphone-5).

An egalitarian view: distributed, sustainable economies via creative communities

"The egalitarian has a risk-averse, precautionary, attitude. The egalitarian society is characterised by operating in social groups, without too many binding rules, and with a high level of equality. Thinkers from this strand hence put much emphasis on the question of whether 'small' people can organise their own lives in a way in which they like: people should be able to determine their own destinies, and to learn and grow from work and other experiences, rather than being the passive beneficiaries of structures that take care of them – or, worse, that exploit them…….Implementation of alternative technologies for the production of energy based on, for example, the sun and hydrogen, would not only reduce the global warming problem, but would also lead to a 'distributed economy' consisting of microplants set up close to the end-user, a democratisation of resources and energy, enabling individuals, communities and nations to reclaim their independence. Such localised social networks of stakeholders tend to pay significant attention to preserving (resource) renewability…… The (alleged) positive environmental, sociocultural and political implications include the following:

- Socioeconomic implications: by bringing a large part of the value creation process to a local scale, distributed economies generate, and maintain, local wealth and local jobs. They intensify local activities and interactions (or social fabric) and prepare a favourable ground to optimise the use and regeneration of existing social sources
- Environmental implications: by reducing the scale of their individual elements, distribution systems permit the optimal use of local resources and facilitate forms of industrial symbiosis that reduce waste. By bringing production nearer to local resources and final users, they permit a reduction in the average transport intensity of activities (and, therefore a reduction in congestion and pollution)

- Political implications: by bringing the power of decision nearer to final users, and by increasing the visibility of the systems on which decisions have to be taken, distributed systems facilitate democratic discussion and choice. Since those advantages and problems that are related to a choice can be better compared, such systems facilitate individuals and communities in making responsible decisions. "

The critique on this paradigm is that it seems to be a nice dream but highly inefficient in practice. The underlying assumption that 'people are born good' and 'are eager to share what they have' should be questioned as well. If people really want such communities, and such a system really delivers happiness and well-being, why are they still so marginal after they have been tried out during the period of the Jugendstil and the period of the Flower power in the 60ies and 70ies?'

A hierarchic view: sustainable development via a master plan

"This last paradigm is probably more a strategy on how to realise the goal of sustainability than a suggestion of goals in themselves. It relies heavily on a top-down approach in solving problems. In its extreme form an all-encompassing blueprint is developed and executed in an orderly, planned and stringently controlled fashion, all under the guidance of a central power. This type of approach to transition management is supported probably by those who call for a 'master plan' or 'Apollo programme' (Dutch: 'Deltaproject'; example in Germany: 'Energiewende') to save the environment…… A moderate version of this approach would be to organise a number of binding treaties with strong environmental demands and targets.

The obvious weakness in this model is that it rests on a high level of centralised power, even at a global level. This is hardly a realistic proposition in a time where influential scholars have announced the advent of a 'network society', where power of the nation-state is perceived as declining in comparison with corporate organisations, and when supranational organisations in the field of sustainability have only a limited influence."

Although there is much truth in the abovementioned weakness, Europeans tend to prefer a mix of individualism and hierarchic governmental actions, provided that these actions are the outcome of a democratic process. This book on Eco-efficient Value Creation has been written in the paradigm of this West European culture.

Appendix XI

Summary framework for sustainable business strategies

This book on Eco-efficient Value Creation describes the opportunities and threats of companies (Section 2), product portfolio management (the examples in Section 3 and 4), the essence of customer perceived value (Section 5) and the way to enhance it (Section 7), green marketing (Section 8), and how products and services can be bundled in a sustainable way (Section 6). All these issues are related to innovation of product and services in consumer markets. The question is with what to start with in practice: what is the main focus and what are the most important operational actions to be taken. As explained in Section 8.1, the strategy in consumer markets depends on the characteristics of a consumer market (the type of business). Fig. A13 gives a summary of the main focus and the main operational actions which have to be taken.

Furthermore, the question is what to do in B2B markets, since the products of these markets are only linked to the end-user in an indirect way. Section 9 gives guidance in the field of investments and the timing of it, and deals with the important issue of procurement and supply chain management. The B2B industry is characterized by long lead times, which requires careful planning of actions:

- the risk of being reactive is that the results of a change of strategic direction are too late, leading to loss of market share
- the risk of being proactive is that the payback time of the investment is too long, leading to relative high additional product costs and loss of market share as well

The conclusion is that the B2B industry must *prepare* for change and manoeuver in a strong position for changes in future markets. This means:

- R&D: minimize the EVR of new innovations, and explore cradle-to-cradle supply chains well in advance
- Corporate: build a strong brand image, and make eco-costs transparent for all stakeholders
- Production: make a long term investment planning, and stay alert for new process innovations and governmental regulations
- Trade: make the eco-costs of products transparent for the buyer (provide the buyer with a green choice), and prepare for switches in the supply chain

Direct business results are in the consumer markets are:

- higher profit margins in environmental niche markets and high quality markets
- higher sales volume in mass markets

Direct business results in B2B markets are:

- a strong front runner position in supply chain
- a low risk of sudden non-compliance with strict governmental regulations, and a low risk of sudden reputational damage
- being attractive to talented employees,

which will lead to higher earnings (a high quality position in Fig. 7.2).

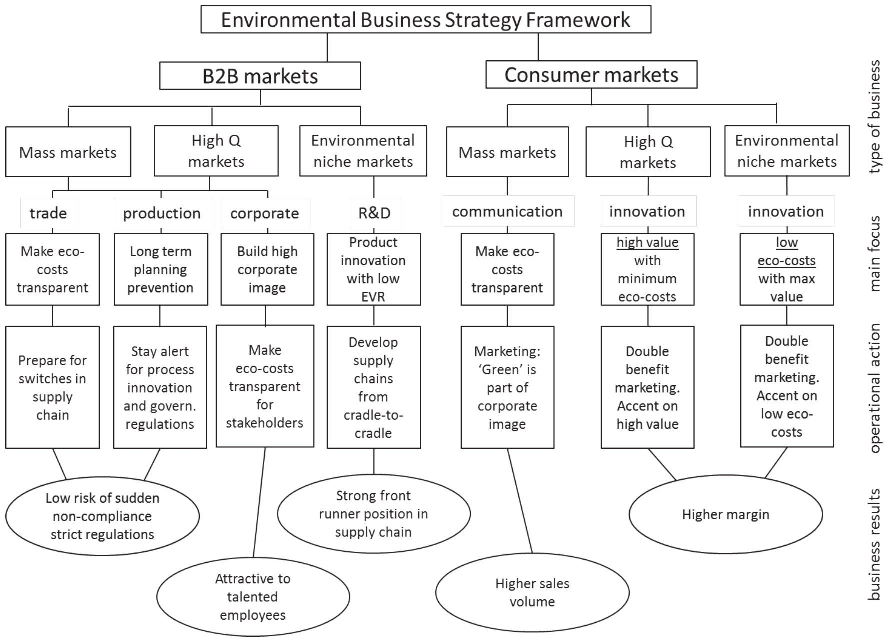


Figure A13

Environmental Business Strategy Framework

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Note. This reference list is as short as possible, since this book must be regarded as a practical document, not meant as a literature study for scientist. Long reference list can be found in [4], [6], [7], [8] , the Master thesis mentioned in Section 8.3, the Doctorate theses mentioned in Appendix VII, and in the books of Garvin, Gale and the publications of Kano (mentioned in Section 7) and Ottman (Section 8.1).

List of Figures and Tables

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Eco-efficient Value Creation

It is widely recognised that sustainability is a major issue in the long term development of products and services. Drastic reduction of pollution and use of materials is required to preserve our mother nature, and share our quality of life with the poor people of our world and with future generations. The growth of the world population emphasises the need for a new approach. From the Brundtland report: *"what we need now is an era of economic growth, growth that is forceful and at the same time socially and environmentally sustainable"*. For products and services, sustainability is no optional extra, but a prerequisite for success in competitive future markets.

The challenge is clear, but putting it into practice is not easy. How do you design products for the sustainable future? How do you have to shape your company and make it fit for the coming decades? What are de do's and the don'ts? How do you avoid the common pitfalls of being too costly, having the wrong marketing approach, and making the wrong investment decisions?

This is where *Eco-efficient Value Creation* comes in. The book shows how designers and engineers can contribute to the required shift towards sustainability and what this means to product portfolio strategies of companies. The way towards sustainability requires a 'double objective' for the designer of new products. Designers must create products with lower eco-costs, and at the same time higher value (a higher market price). This book gives many practical design cases, and shows how to develop a sustainable business strategy.

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