Human and ecological problem solving through radical design thinking

Analyses and development of design
theory and design framework
based on long-term human needs
and ecological sustainable principles

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Kristin Støren Wigum

November 2004

Preface

This thesis is part of the research programme Productivity 2005 which was established in 1998 and supported by the Norwegian Research Council (*Figure 1*). The research programme initially had three branches that were later expanded to four. The branch of Industrial Ecology, initially managed by Prof. Helge Brattebø, focuses on two core areas, where core area 1, Eco-efficient Products and Production Systems includes the discussion of the factor 10 [1]concept.

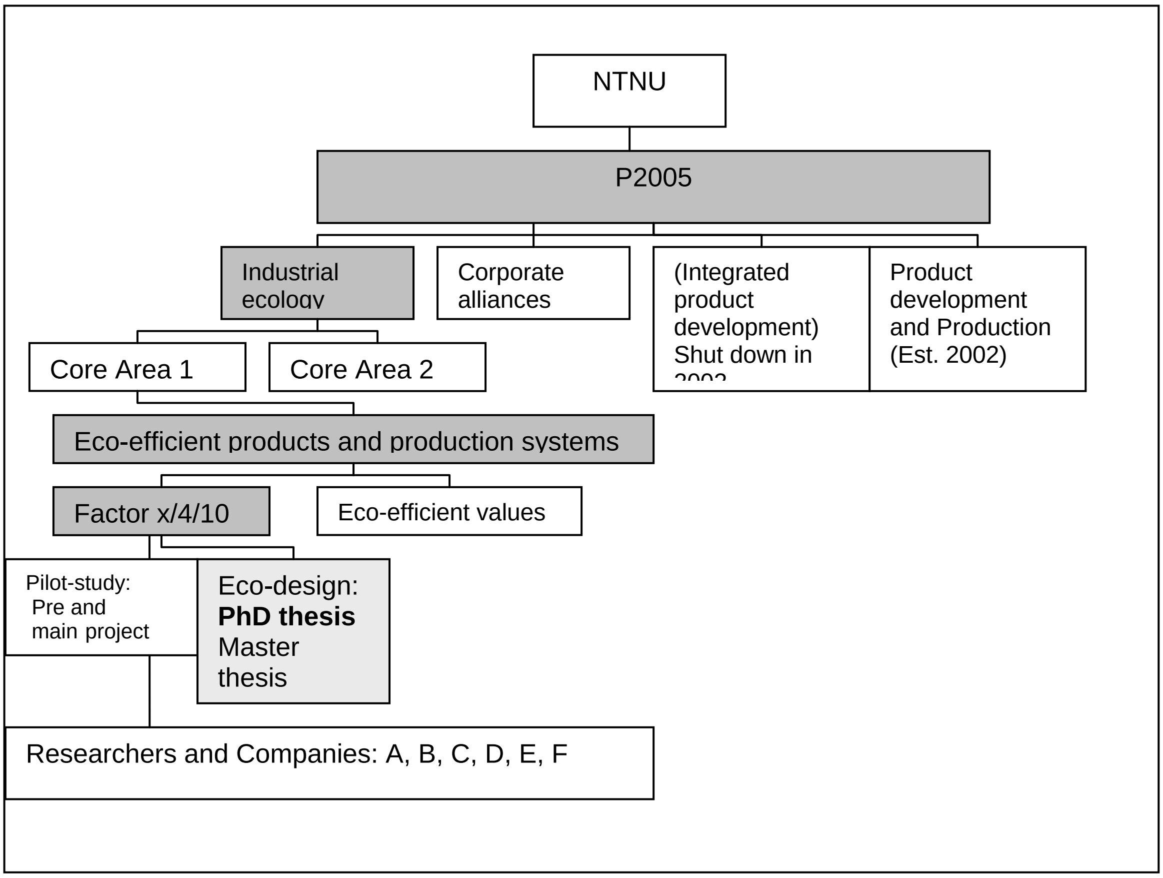

Figure 1 Productivity 2005 research programme with its structure in the branch of Industrial Ecology (source: http://www.p2005.ntnu.no/iok/aktiviteter)

Ole Jørgen Hanssen, associate professor at NTNU and senior researcher at Østfold Research Foundation (STØ) has supervised the PhD thesis and has also been responsible for core area 1 in the research branch of industrial ecology within the P2005 programme.

Initially this thesis was intended as a study of LCA as used in product design processes, however, this was seen as too narrow a focus in a factor 10 perspective. My personal motivation is my interest in life quality as an underpinning of design for sustainability. New solutions must introduce improvements on a human scale by challenging the senses and solving fundamental needs in an interesting and beneficial way.

[1] See Chapter 1.4.1 for an explanation of the term. Factor 10 is a concept evaluating long-term prognoses from a global perspective, considering total resource consumption, economic welfare and global population and sustainability.

The work in this thesis has also been propelled by the “need” to find the core issues in the sustainability concept, to elaborate on the important qualitative principles and f to see how these actually can be brought into discussions and raise awareness of design of new solutions in practice.

Work on these ideas began in the autumn of 1996 in my graduate thesis at the Department of Industrial Design, at the School of Architecture in Oslo. To raise products to new dimensions of sustainability, the designer might have to look into new disciplines and most likely develop the existing design methodology. The conceptual phase of the design process will depend on asking basic questions and finding quality answers, thus making the chosen values visible as a framework for the total product concept. If the product can satisfy the users' actual needs, support the users' identity and be a carrier of spiritual and non-material values, we might not need as many products and might not need to exchange them as often as we do today as substitution for missing values (Papanek 1995) (*Figure 2*, Wigum 1996) (Stuart Walker 1999).

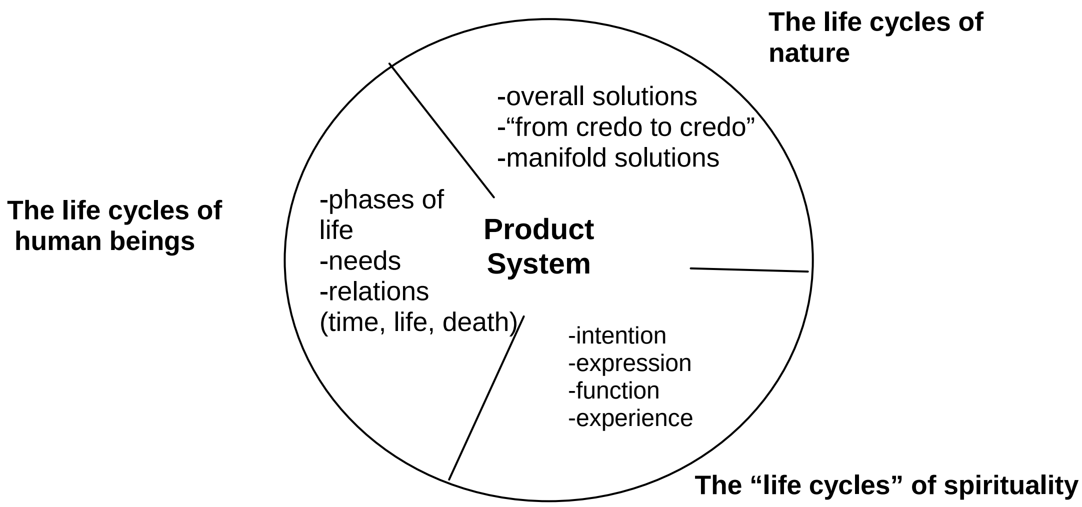

Figure 2 Illustration of a possible holistic approach to product concepts, combining abstract aspects with concrete material elements through cyclic definitions (Wigum 1996).

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Internet:

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Index

“Hva er fremskrittet? At vi kan kjøre fortere på veiene? Nei, fremskrittet er legemets nødvendige hvile og sjelens nødvendige ro. Fremskritt er menneskets trivsel.”

Knut Hamsun (1859-1952)

“What is progress? That we can drive faster on the road? No, progress is the body’s necessary rest and the soul’s necessary peace. Progress is humankind’s welfare.”

To Mathilde and Benjamin

1.0 Introduction

This chapter provides an overview of the terminology and world perspective which is the foundation of the thesis. I also present my view on design and research to show the basis of and starting point for this thesis work. The chosen research approach, based on a gradual development of the research questions, is briefly described to point out the extent to which the paper embraces the theme of design for sustainability. Finally the chapter structure of the thesis is presented and briefly described to guide the reader according to interests. To share the spirit of this thesis with the reader, the next section will briefly describe the starting point of this work.

1.1 The context

The global pressure on natural resources, toxification of the ecological chains and disturbance of the natural balances we see today are mainly caused by human activity based on unsustainable ideas, goals and solutions. Moreover, it is estimated that the world population will dramatically rise to 10 billion people by 2050, which is almost a doubling of today's population in 2004. To respond to future generations and their substance needs, the earth's annual carrying capacity is estimated at only half of today's total use of materials and resources. To this story we must add the challenge of distribution of goods and the guarantee of welfare. Currently, at least 80% of the material and energy in the world is consumed by less than 20% of the total population. To meet the required change in global equity and sustainable consumption of materials and energy, this 20% must reduce their consumption by 90% (factor 10). This is defined as the factor 10 concept.

On the one hand, this situation calls for a radical change in modern ways of living, which may seem impossible to achieve. On the other hand, it is a most interesting and meaningful start for development of new design solutions. However, can our existing design methods result in new products which are 90% less material and energy demanding? Is it sufficient to look at single products to achieve these results? What are the driving forces that make individuals consume in an unsustainable manner?

Current eco-design methodology includes a broad range of approaches based on either a humanistic or technological focus, and with a long-term or short-term perspective. However, the sustainability issue is complex where all the factors and problems are interconnected.. As mentioned above, the term sustainability indicates a long-term perspective. An additional complexity is therefore the short-term economic pressure within a business economy, in contrast to long-term planning and making investments for future gains. Sustainability is not a definite state of the earth's situation, but it is a rhythm and movement which is durable and promotes non-destructive development of all living things. This rhythm may be represented in cyclic patterns and waves. The development of non-material character (e.g. consciousness) may be represented by spirals.

The triadic definition of sustainability with the three ecological, economic and social pillars may be supplemented with a fourth pillar, the spiritual aspect.
This nature of sustainability invites us to look at environmental disturbances through a system perspective and in a holistic manner, which includes material and non-material elements, i.e. what we

cannot define as physical objects, such as individual experiences, essential motivation, social values, ethics, spiritual understanding and so on. This is important if we are to find viable solutions that include human behaviour and cultural dimensions.

A holistic design methodology should therefore include an integration of life-style focus, system thinking, short-term steps in long-term planning and guidelines based on sustainable rhythms and movement (principles). Both material and non-material human needs should be represented in the premises for new solutions. This type of methodology therefore demands human collaboration, interdisciplinary cooperation, conscious treatment of ethical values and a combination of quantitative and qualitative analyses.

1.2 Terminology

The terminology applied in the various discourses on human-inflicted threats to human life and nature is in the development stage. Consequently the varied understanding of the terms and their application which we experience today might reflect that this area of research and practice is very young and still unclear from many perspectives. Although groups of researchers precisely define their terminology, this does not necessarily guarantee that there is a common understanding. The use of words and expressions will probably mature in step with the general understanding of the content and complexity of ecological issues. Below I will give brief descriptions and definitions of the most important terms used in this thesis.

Ecology originates from the Greek *"oikos"* which means "home" or "household" and *"logos"*, which means "knowledge". The term is used in the natural sciences about species and nature per se, e.g. describing the biotope and life premises of each creature. Ecological life cycles, food chains and material flows describe the connection between the "homes" of each life form. Humans are a part of these cycles and chains, however, as a species we have designed our own systems of homes which are not necessarily in balance with the original ecological meaning of "*oikos*".

Environmental impact is a rather new phenomenon seen from the perspective of human existence. This indicates how far away our product and system solutions are from being in line with the natural ecological systems. In many cases today, humans are a burden on the environment rather than a participant in the natural system flows on both the macro and micro levels. Waste is a non-existing element in the natural systems. The amount of waste in human-created systems is therefore one of many indications of flaws in our thinking on the use of resources.

Sustainability was introduced as a term in 1987 (the UN World Commission on Environment and Development (The Brundtland Report)) in the context of human life style, consumption and the exploitation of natural resources. Calculation of today's Western consumption distributed over future generations will demand the resources from four planets. Because of the asymmetry of resource use and resource recovery, the term sustainability introduces a new dimension to the term environmental impact, namely the need and demand to decrease consumption in the industrialized world and to distribute resources equally between nations and generations today and in the future. Principally, total consumption and output of emissions must not exceed the natural reproduction of resources and the cleansing capacity of nature.

The Brundtland definition of sustainability (1987) is literally: "Sustainable Development is to ensure that humanity meets the needs of the present without compromising the ability of future generations to meet their own needs." The director of the International Society for Industrial Ecology, John Ehrenfeld, has the following definition of sustainability (2003), which he used in his study of the use of metaphors in industrial ecology: "Sustainability is the possibility that human and other life will flourish on Earth forever… Flourish means not only survival, but also the realization of whatever we humans declare makes our life meaningful: justice, freedom, dignity…"

It is difficult, if not impossible, to measure the degree of sustainability in a society or business. However, some nascent attempts have to this point included indicators of economic, environmental and social performance. Known as "the triple bottom line ", a few companies have presented sustainability reports based on a selection of measurable indicators within each of these dimensions (Fiksel 2001).

“Weak” sustainability is defined by Hueseman (2003) and others as a strategy which includes to some extent the use of non-renewable resources, such as metals, minerals and fossil resources. This should be thought of in a cautious way through loop-closing and limited extraction. “Weak sustainability” may be a realistic approach towards sustainable development, but will also demand substitutes for the non-renewable resources in a long-term perspective. In terms of energy, renewable sources must also become the dominating alternative in a long-term perspective.

“Strong” sustainability is a strategy without compromise. This is a clear approach towards renewable materials and solar-based energy sources. While it might be the type of strategy that does not wait for society and individuals to “wake up” and understand that a change in thinking is necessary to survive, it is rather dominated by a top-down management process including radical solutions and system change. “Strong” sustainability might also be based on a precautionary evaluation of the signals from nature, as James Lovelock points out in a newspaper article (May 2004) on climate changes and available sources for clean energy. Lovelock sees no other option than to introduce nuclear power sources today, replacing all coal and other fossil-fuel based systems, to slow down the accelerating process of climate changes caused by the emission of climate gases (such as CO_2). The way Lovelock understands the global situation, we do not have the option of experimenting for 50 years, which is the time it might take to design and develop sustainable solar-based energy transformers.

Eco-efficiency is a supported strategy by corporate leaders and organisations. The World Business Council for Sustainable Development, WBCSD invented the term in 1992, defining it as the pathway to industrial sustainability. It describes economic growth in general, including environmental protection through dematerialization, demand-driven economy (service extension), closing production loops and increasing product value through function extension (WBCSD 1997-2004).

“*Eco-efficiency* is reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality to life, while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the earth’s estimated carrying capacity” (WBCSD by Lehni 2000).

$$\frac{\text{Value added (economy)}}{\text{Environmental impact + resource use}} = \text{Eco-efficiency}$$

The higher the number describing the eco-efficiency, the better the level of eco-efficiency.

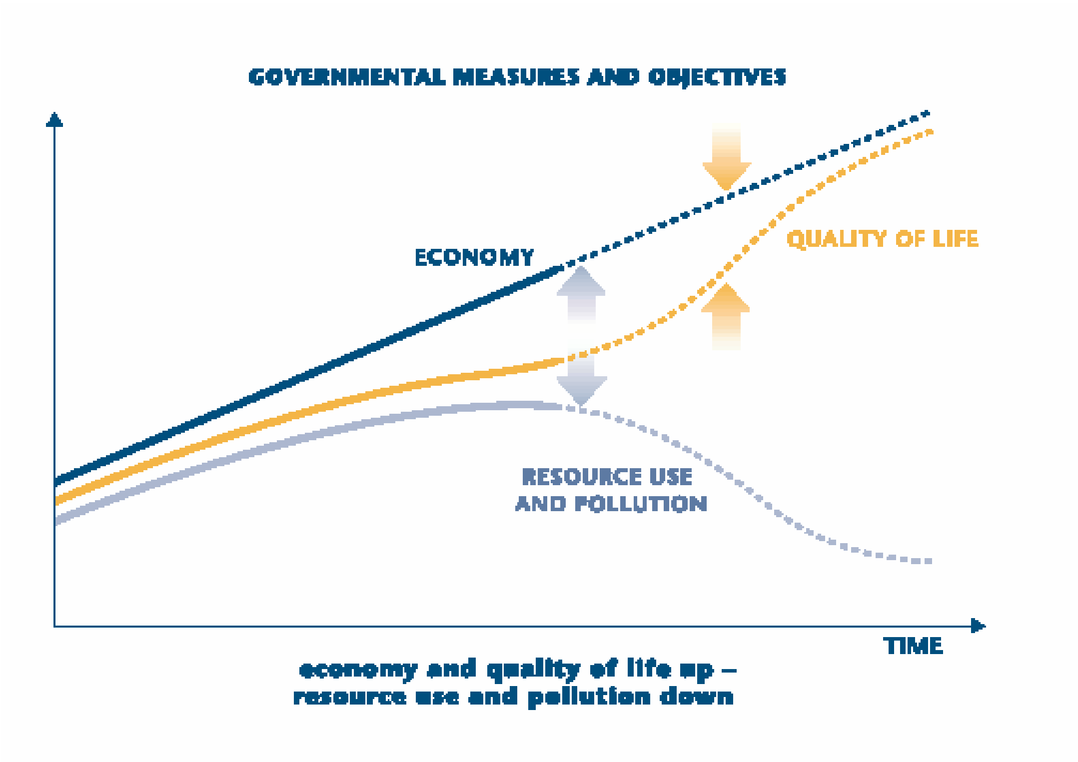


Figure 3 WBCSD's vision of the eco-efficiency concept (Lehni 2000).

In their e*co-efficiency report* (Lehni 2000), the World Business Council for Sustainable Development describes how sustainable development following the principles of eco-efficiency contributes to continuous growth in the economy and life quality, while at the same time it reduces resource use and pollution (*Figure 3*). In terms of rebound effects and the second law of thermodynamics, this combination might seem impossible (Hueseman 2003) (See Chapter 2).

Businesses today operate within an economic system that most likely contradicts the concept of (ecological) sustainability. Short-term economic investments based on the idea of continuous growth in economy appear to be the opposite principles to long-term evaluations and reduction in total material and energy consumption (Hueseman 2003).

Whereas eco-efficiency focuses on the environmental performance of one product or service compared to a reference product/service, *eco-effectiveness* has been proposed as a measure for the total effect of a system or a function (McDonough, Braungart 1998, Jakobsen, Støren 1999). It is described as "doing the right things (eco-effectiveness), not just doing things right (eco-efficiency). For example, a car can be improved according to the principles of eco-efficiency, but the infrastructure of transportation is still unsustainable. Eco-effectiveness includes evaluation and new development of the total system of mobility and transportation, not only improvement of means of transport, such as the private car.

Design for sustainability and *sustainable design* may also be seen as two different perspectives or approaches. *Design for sustainability* emphasizes the purpose of the design, the intention, appropriate functions and answer to fundamental needs. It may be compared to eco-effectiveness and "doing the right things". *Sustainable design* is rather "doing things right", however, it may be questioned if design itself can be sustainable if it is not placed in a context of activities and consequences in a certain time perspective. *Eco-design* can be seen as a better definition for this type of design focusing on material and energy use, emissions and the total life cycle, including next life. Design for sustainability should result in products and systems that eventually are based on eco-design principles, however, within a set of ethical and sustainable values (see Chapter 2.3.2).

This paper focuses on a system level for products and services and explores how systems can be designed in a holistic manner to actually promote change in material perspectives but through a quality of life and satisfaction of fundamental needs approach. Nevertheless, this thesis will try to avoid the two terms eco-efficiency and eco-effectiveness, because as terms and in context they are both associated with economic perspectives and high-tempo activities. While not necessarily negative, this does not promise a change in today's systems, rather business as usual at an even greater pace. There is also a language problem in these two definitions as the Norwegian language does not distinguish between efficiency and effectiveness, which might also be the case in other languages. Additionally, the two words have no self-explaining reference, and they do not represent the generosity and flourishing qualities that could inspire design teams and promote conceptual thinking (McDonough and Braungart 1998). Design for sustainability and eco-design will be the preferred terminology.

Short- and long-term are most certainly relative descriptions of time, in a business context one year can be a long time. In this thesis, long term is evaluated as at least 20-30 years (one generation) or more. Short term is less than five years. This is loosely defined related to change processes in society and nature rather than to business.

1.3 Historic view, perspectives on design and future complexity

1.3.1 Roots and characteristics of industrial design activity

In the field of industrial design, the main action is the design process and the use of existing knowledge within many other fields to create a holistic product for industrial production which is fulfilling certain needs (Øritsland 1999).

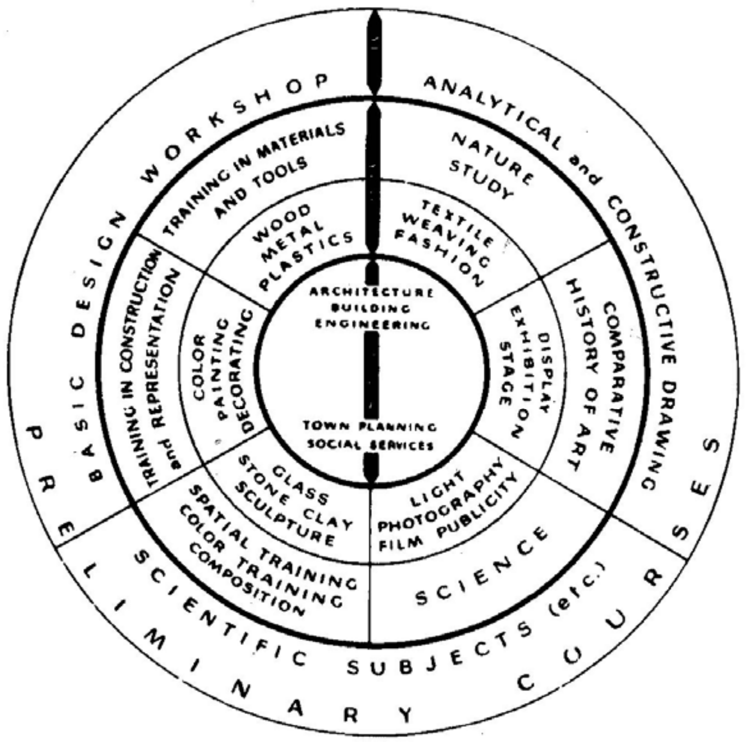
It is not reasonable to assume that a single approach model will characterize the design process for everyone (Margolin 1989). There are several approaches represented by various focal points and educational profiles. Industrial design from the various schools of arts and crafts is based on humanities traditions and is rooted in traditions within crafts and certain areas of art which were slowly adapted to the design of products for industrial mass production. This evolution differs from mechanical engineering design, which is based on the construction of mechanical machines for industrial production, and the development of infrastructure for transportation in society (Stolterman 1984).

The industrial revolution challenged the artisan and handicraft dominated society on several levels. New concepts and practical approaches radically changed economic systems, educational profiles, social settings and the daily way of living. The craftsmen in the European countries represented cultural traditions, and national local roots were found in their work. (Naylor 1985) The Bauhaus ideology was focused on this issue, and chaired by Walter Gropius, this school of thought wanted to form a unity between craftsmanship and art, at the same time uniting architects, sculptors and painters. The students were trained in craftsmanship, artistic techniques and theoretical knowledge.

The American school of industrial design in the beginning of the 1920s was related more to the sales and economic benefits gained from differentiating industrial products from one's competitors and increasing consumption. Henry Dreyfus was one of the first famous American designers and was known for the design of a new generation of trains. However, this approach to design is related to the term “styling” which is a rather external treatment of a product. The approach with roots in craftsmanship is based on the idea of working both from “inside and out, and from outside and in”.

Herbert A. Simon (1916-2001) has a broad definition of design. His definition starts: “Everyone is a designer who devises courses of action aimed at changing existing situations into preferred ones“. Simon ends his definition “….Design, so construed, is the core of all professional training: it is the principal mark that distinguishes the professions from the sciences” (1969).

The extended view on design, focusing on change and also embracing non-material aspects, such as services, is not a new approach. The New Bauhaus school of thought in Chicago, initiated in 1937, included social services as a part of the design tasks in the product design workshop, however, on the border of town planning and architecture (Findeli 1995).



Findeli, *Moholy-Nagy's Design Pedagogy in Chicago (1937–46)* 31

Figure 4 The curriculum of the New Bauhaus school, developed by L. Moholy-Nagy (Findeli 1995).

The New Bauhaus school in Chicago, led by László Moholy-Nagy (1937– today, Institute of Design located at the Illinois Institute of Technology), had two important additions to the original Bauhaus idea: The artistic component in the curriculum was supplemented by more technological arts, including photography, film, light sculpture and non-visual arts (e.g. music and poetry). In addition to art and technology, this education included science, such as the social sciences, physics, and life and human sciences. This dialectic between theory and practice, art and technology, is fundamental to the philosophy of the Chicago curriculum, but is also characteristic of the nature of design, essentially a paradox. Another feature is its multidisciplinary content, or transdisciplinarity.

According to the above-mentioned elements of design, this adopts the view that the industrial design process can involve both material and non-material concepts of functions and totality, and the design process as such is not a scientific activity. Needless to say, it may be enriched by scientific studies, both independently and directly connected to design and related to specific research projects with a focus on design. Research on different aspects of design should provide the field with new knowledge and awareness, and lead to new methods that can improve the final results. However, the freedom of improvisation, ad hoc solutions and practical compromises within the design process will always be necessary to complete a design project.

1.3.2 Focus on function or message? Design based on different ideologies

From 1900 to 1960 the modernists among designers tried to align design thinking with scientific and technological values. The Bauhaus school (1919-1933) wand Walter Gropius were part of this paradigm. They believed that optimum solutions to design could be found through objective communication and processes. As a part of industrialization, the modernists were influenced by social progress which provided paradigms for design thinking seen in connection with technological innovations (Margolin 1989).

Moholy-Nagy saw the designed products and artificial world as a parallel to nature's "production". This meant continuous improvement and refinement of human-made things throughout history. The difference to nature was the speed of trial and error, and Moholy-Nagy therefore underlined the designer's need to develop stronger techno-scientific knowledge and aesthetic judgment. He added to Louis Sullivan's expression "form follows function", "form also follows – or at least should follow – existing scientific, technological and artistic developments, including sociology and economy. In his work, Moholy-Nagy introduced the term "*organic functionalism"*. His background was as a teacher and designer from the original Bauhaus school in Germany where functionalism as a way of thinking and designing was developed.

Moholy-Nagy found that it was necessary to educate students from having a rather unconscious attitude towards their work to being fully aware of their responsibilities in a design occupation. Through a three-step process the students would solve design tasks: 1) observation, perception and description, 2) systematic exploration and analysis, and 3) conscious manipulation and action, leading eventually to a mastery of design. With this model Moholy-Nagy tried to introduce a scientific profile to the design process based on a dynamic relationship between art and scientific knowledge, transformed into material and technological means (Findeli 1995). The first Norwegian curriculum in industrial design (initiated in Oslo in the 1970s and today taught at the School of Architecture in Oslo) was inspired by Moholy-Nagy, both in terms of his pedagogy and design philosophy.

Post-modernism represented a counter-culture that also appeared in the design discourse and practice as an answer to the rapid introduction of new technology that demanded a fundamental realignment of human-machine relations, and a revision of certain aspects such as human-ecology relations. Post-modernism in the field of industrial design is manifested by diverse characteristics. However, Maurizio Vita describes postmodernism according to the growing role that images play in contemporary culture (Margolin 1989). Communications and media, advertising in particular, motivate people to act (which is mainly to buy) through visual presentations. Other designers understand the exchange and owning of goods as also a social and symbolic act, and as part of communication through the medium of objects (Margolin 1989). The products themselves become a medium of abstract ideas and messages, which invites a broader diversity of physical shape, structure, materials and use of digital technology.

Post-industrialization is represented by a continuous transformation. Flexible manufacturing and diversity give the customers the power of choice, a further attribute of the post-modern culture (Margolin 1989). On the other hand, the globalisation of the economy and marketing is also spreading mono-cultured design and system concepts worldwide. Values and lifestyles follow as meta-images through the commercial promotion of the products and influence local traditions and ways of satisfying needs.

This dissertation will focus on values consciously integrated in design solutions, and adapts a combination of the modern and post-modern view. The belief in finding solutions that are better than others in terms of supporting increased quality of life and sustainability is linked to the modernistic paradigm. But this thesis also applauds diversity in design solutions, cultural richness and local identity represented in both material products and non-material values. These qualities are related to post-modern ideas.

1.3.3 Industrial design challenges in meeting with digital technology

Designed objects have been defined as extensions of the body or prostheses of the body.
Human services have always contributed as function deliverers in many contexts. A new aesthetic dimension and supplement to the physical forms of objects was introduced in the design discourse about 15 years ago; the immaterial (non-material). A prostheses of the mind, "Beauty or terror", as Margolin (1989) presents it, is created through feedback on intellectual and sensory experiences, which the user evokes through a keyboard, control panel or displays. The non-material qualities (often defined as immaterial by researchers who do not have English as their native language) are, however, in this context referred to as the digital functions and consequences that emerge from digital technology and its nature.

The non-material aspects of design are more than these high-technology ideas presented in the late 80s and beginning of the 90s. The digital solutions have, however, been described as ubiquitous and pervasive computing (Tackara, 2001). Functions, information and communication channels are integrated in all types of user situations and the simple three dimensional interaction between a product and a human being will soon be a rarity for industrialized products. (Soon your kettle will send an SMS to your mobile phone when the water is boiling; if you want it to…).

The ICSID (International Conference Society for Industrial Design) held a conference in Milan in 1983 where one of the participants, architect Ernesto Roger, claimed that designers could create anything from “a spoon to a town”. The designer Andrea Branzi replied that the designer’s role was to make everything from a “spoon to a spoon” (Margolini 1989). It might seem that the non-material, or rather digital dimension might be an even more challenging dimension for designers, involving the complexity of interpreting human nature within the new extreme access to functions that we are exposed to daily.

In his article “The future is not what it used to be” Victor Papanek (1995) discusses human ecology and how requirements for surroundings, colours, air quality and surface textures are aligned to the qualities in nature. In his comparison, the human-made environment is so far rather primitive and lacking in many of the qualities that humans need to remain healthy, both physically and mentally. On the contrary, people are exposed daily to humanmade solutions which may lead to allergies, depression and a lack of well-being. Papanek urges designers to seek knowledge within other disciplines and research fields to respond to some of the challenges in society. He points to research showing how stimulation of the senses affects blood pressure, as in how meditation and the scent of spiced apples reduce blood pressure.

If the curriculum for design education is assessed, it might be that neither of the arguments of these two designers, Branzi or Roger, is right in terms of what designers actually can execute and what role they should play. When we see digital and “non-material” functions even entering products of an artistic nature, such as jewellery, then the borders of roles and knowledge of design and technology are moving the traditional design approach into a new and wider frame of expertise.

The photos below (Form 2/2001)(*Illustration 1* a and b) illustrate how Ideo (a design bureau in the USA) imagines the mobile phone as jewellery on the thumb and little finger. The ornamental GPS toes are linked to a geo-satellite through a radio amplifier.

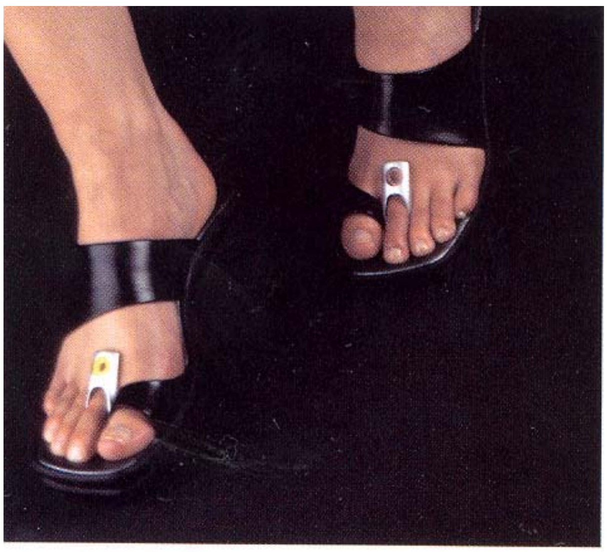



Illustration 1a and b Design: Ideo, Cellphone Rings and GPS Toes (Form 2/2001).

1.3.4 Comment on other existing eco-design methods

Designing within a new framework that takes ecological and natural boundaries into consideration mainly opens up for new ways of thinking, but also introduces limitations on the use of some of the existing typical design solutions. Long-term ecological perspectives demand new development in technological, material and processing approaches, and also in terms of management, marketing and launching of products. The goal for a new solution will include an economic, ecological and social bottom line (Allenby and Richards 2001)(Fiksel 2001). This should affect design methodology and decision making on different levels in the design process, depending on the type of design project.

In the process of designing a new product concept, the means come later, the purpose and vision come first (Næss 1989). The strategies for a new product should support the vision and the vision should be consciously built on relations to human needs and nature, in other words transdisciplinarity. However, eco-design and industrial design are currently most often practised for incremental improvements, where there is little room for questions of an existential nature. This thesis will therefore challenge the position of the design function in traditional Norwegian companies and challenge the traditional working processes with a short-term duration and detailed product focus.

1.4 The global resource perspective and design for sustainability

1.4.1 The factor 10 concept; a quantitative abstraction

“Factor 10” is an expression inspired by various theories and research work, such as the Factor 10 Club (1995), the Wuppertal Institute, Germany (Weizsäcker et. al. 1997), and the “Sustainable Technology and Development” programme, Netherlands (Jansen, 1998; Weaver, 2000). The various researchers use a broad approach based on quantitative analyses and prognoses of the growth in the human population, increase in welfare and the carrying capacity of the world. The number ”10” represents the demand for a per-capita drop in the use of materials and energy in the Western world, but is explained by different parameters and therefore appears as a variable from 4 to at least 50.

During the 1990s many case studies and research programmes explored environmental issues of product design and development (Hanssen, Wigum 1998) (see Chapter 3, and Appendix I). A methodology for the total design process and different methods for analysing certain aspects of the product and its lifecycle have been created as tools for the future or for the development process, such as Quality Function Deployment(QFD), Life Cycle Assessment (LCA) and Life Cycle Cost (LCC).

In spite of these increasing activities, the prognoses for future generations and facts about the environmental status today indicate that more radical changes are needed in Western society, but changes are also necessary in the mindset of virtually the entire world's population with respect to ”what creates a good life”.

The Wuppertal Institute in Germany and other research institutions have introduced a new term in their attempt to achieve more radical solutions and ways of thinking. "Factor 10" is based on prognoses concerning the need for material resources and growth in prosperity multiplied by the growth in population of future generations divided by the total carrying capacity of the world[2].The number “10” can also be replaced by the variable x, and is then calculated depending on the time perspective and the location which is in particular focus. The x factor describes the need for a decrease in resource consumption per technical or functional unit.

The numbers that are used for the definition of Factor 20 in the STD inter-ministerial programme in Netherlands (1998) are based on figures from 1992, RNO. We see that these are changing, but the calculation is still valid as a means of showing the change in direction required to meet the future population’s needs:

- Global population: 1998 = 5.9 billion people, 2040 =11.9 billion people
- Global prosperity: 1998 = 20.4 trillion dollars, 2040 =102 trillion dollars
- Global energy consumption: 1998 = 395 qua drillion BTU, 2040 –consumption needs to be cut in half to 197.5 qua drillion BTU

This gives the equation (Equation 1):

½ (50% in total consumption) = 2 (double world population) x 5 (five times multiplied prosperity per person) x 1/20 (95% reduction in material consumption per technical performance per unit of prosperity)

[2] All these prognoses have a high degree of uncertainty. They contribute, however, to the establishment of some dimensions that reveal our unbalanced use of resources globally and in terms of future capability of meeting the population's needs.

The Wuppertal Institute has developed two measures for intensity of material flows: MIPS, material input per unit service, and COPS, cost per unit service (Weizsäcker et al 1997). Still there is much uncertainty in both measuring the results of factor 10 design and estimating the need for resource reduction. Claude Fussler and Peter James (1996) illustrate this issue with their simplified figure (*Figure 5*). While this illustrates a utopia of change, it nonetheless visually explains the vast challenge which the factor 10 concept aims to grasp.

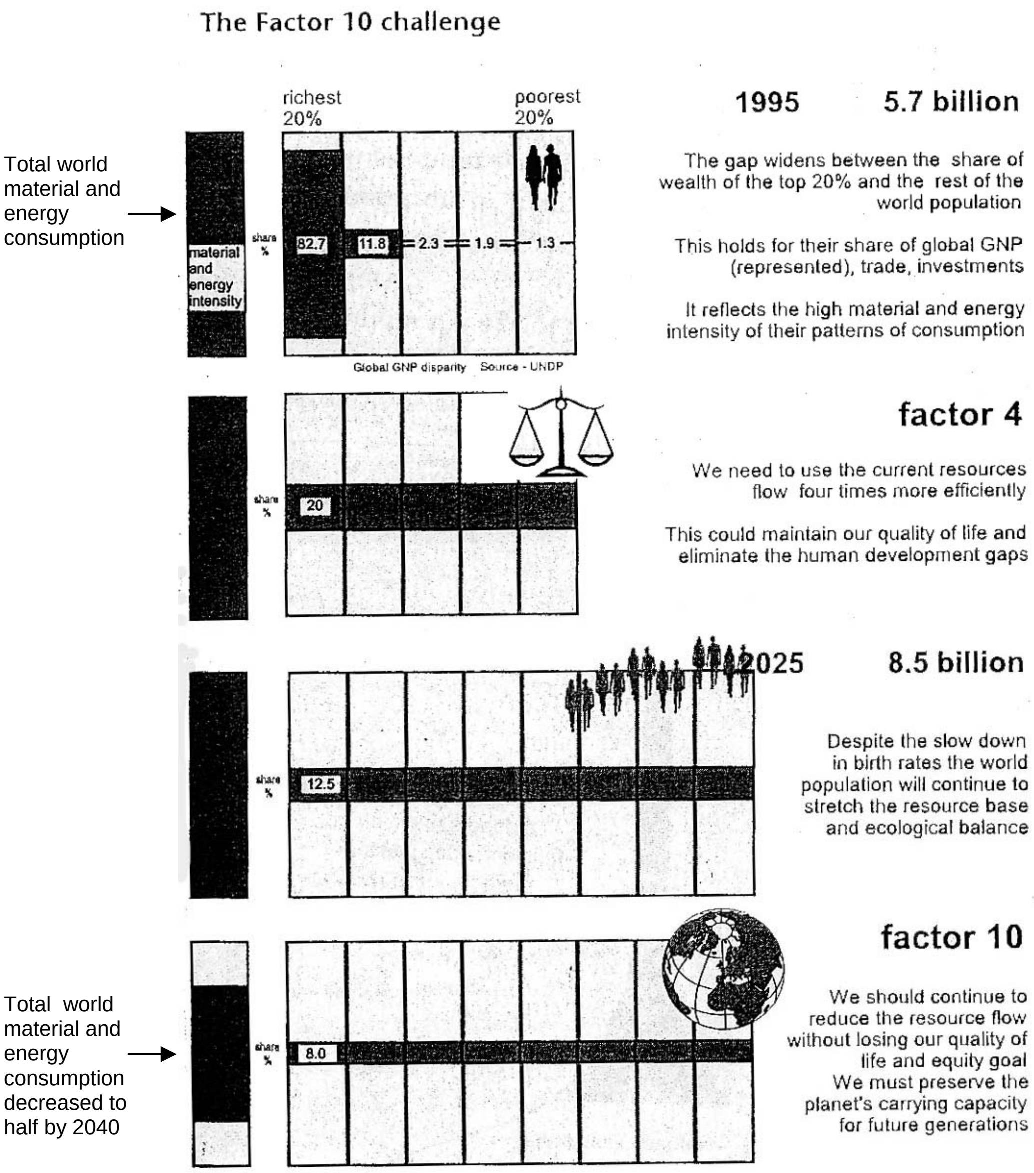


Figure 5 The factor 10 challenge is seen as global resource distribution in a 40-year perspective (Fussler and James 1996).

The challenges we are facing appear to demand a methodology which involves system development based on future expectations and further detailed design of total product life cycles eliminating waste and emissions. There are difficult steps to take in creating the bridge from abstract visions to the concrete total product. In student papers and research projects we have experienced this as one of the most crucial aspects in this type of design process (see Chapter 5). However, solving environmental problems involves all humanity and all professions, cultures and lifestyles. New parameters will always be introduced into in this work. Even if they are all connected, it is impossible to embrace them all in one methodology.

1.4.2 The initiated research for new design practice related to the scope of this thesis

In his thesis (2001) Chris Sherwin found that "designers use general eco-design principles and strategies extensively, rather than numerically intensive or quantified data." Furthermore, designers require more visually presented material, preferably represented through case studies and examples. Typical of the design approach is the demand-side orientation which leads designers to require consumer-oriented and user-centred information. Sherwin concludes in his findings that personal motivations are important prime movers in terms of eco-design as one's individual motivation is to a high degree the prime mover of design projects. Industrial designers are attracted to the novelty and innovation which seem to be an obvious potential in eco-design projects (Sherwin 2001, p.137).

The factor 10 concept is about global and long-term quantitative material and energy distribution and consumption. How to approach this concept in terms developing new solutions calls for qualitative questions and room for great local diversity. Several sources exploring this concept include a strong focus on prosperity and economic growth (Weizâcker et al 1998). There are different approaches to this challenge of finding research and development solutions. The most dominating approach is a technologically optimistic perspective (STD, Netherlands 1997) combined with a claim for economic and political change of valuation. Taxation of environmental impact from production, transportation and waste treatment and a change in focus from material product to service economy are also major shifts expected in the future scenarios (STD, Netherlands 1997). The factor 10 club, one of the initial promoters of the concept, has a rather social angle of incidence. However, most attempts at designing new solutions on the factor 10 foundation do not involve ethical, social and cultural values. The concept should be of interest to various stakeholders, and the individual focus on environmental impact in a global perspective is an attractive starting point for industrial design practice as well. It is a great challenge to create inspiring and stimulating solutions based on only 10% of the average consumption of the Western lifestyle today. This is only possible through new ways of thinking and innovation in many areas of society, both in terms of products and systems but also individual behaviour and value priorities.

The *new solutions* based on the factor 10 concept (Equation 1) are discussed in this thesis as factor 10 design. The steps in the total process developing these new solutions come under factor 10 design methodology. However, the final chapter of this thesis describes a new factor 10 design *framework* i to promote *radical design solutions.* "Radical" points to the new values in this design which the original factor 10 design does not have, namely a balance between material and non-material qualities. This balance should influence the fundamental (principle) structures of the solution.

The factor 10 design methodology should carefully preserve the holistic perspective and embrace the other development and design methodologies (*Figure 6*). If the factor 10 concept is not seen in connection with individual consumption and system thinking, factor 10 designing may fall into the well-known trap of incremental improvement.

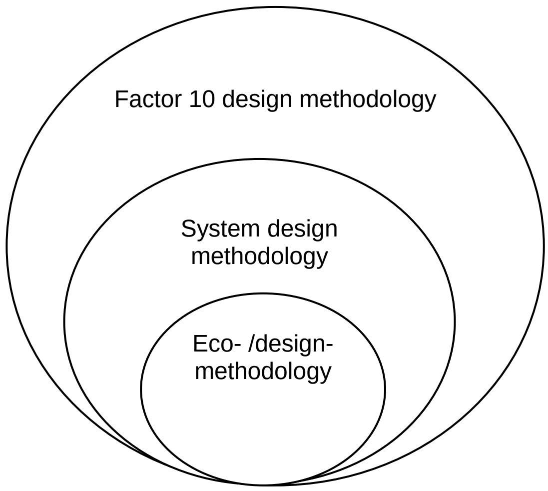


Figure 6 The embrace of methodology (Wigum 2000, with improvements).

More and more research projects and design methodologies encourage long-term perspective thinking through future scenario building, however, the further development of solutions based on the scenarios has a tendency to lead to rather short-term improvements, giving the project group the chance to think just in terms of single products, ignoring the totality or the question of non-material values. The sustainable product service system initiative is an exception to this. Several research projects within this school of thought have been a valuable source of information and inspiration for this thesis, especially the EU funded international project Sushouse, Strategies towards the Sustainable Household (2000) (Appendix I).

Dutch researchers Han Brezet, Jacquline Cramer and Ab Stevels (1997) have made a four-step model presenting the different degrees of new solutions (*Figure 7*). Step 1 involves redesign and single improvements of an existing solution. Step 2 i evaluates the entire life cycle of the product, pinpointing the environmental impact of importance and then changing the product to improve the environmental performance. Step 3 is new conceptual thinking and requires a more open design brief for a wider generation of ideas. This level has the ability to change the existing systems to a larger degree. The fourth step is on a system level in society, which includes infrastructure and organisational structures. This level expands the borders for cooperation and communication for new solutions. With only a few exceptions, all the introduced eco-design methodologies practised and taught today focus on levels 1 and 2. This is in spite of the fact that future prognoses are challenging our existing unsustainable infrastructure and conceptual thinking. However, it is not enough to call for change; the change must inspire us in directions of sustainability. Some basic sustainable principles are described in Chapter 2, and they need to be implemented in products, business activities per se, urban planning and societal-value priorities.

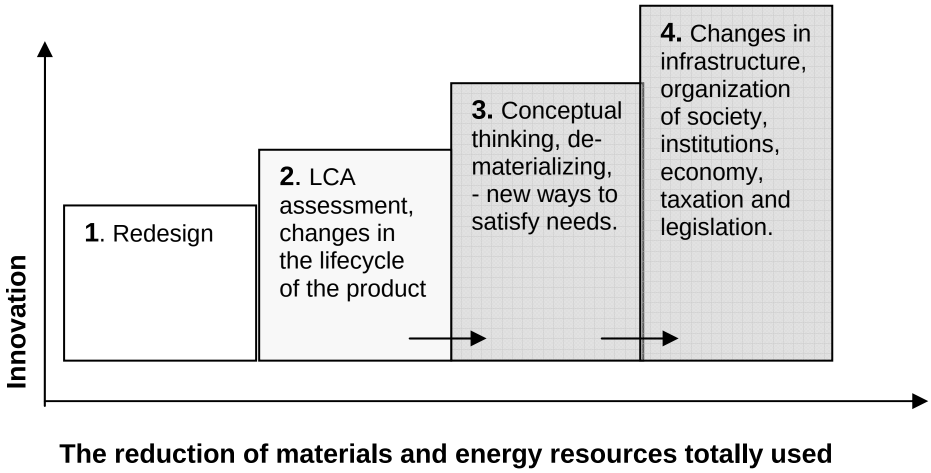


Figure 7 The four levels in eco-design, demanding different degrees of innovation (Brezet, Cramer, Stevels, TUDelft 1997).

Ursula Tischner and Martin Charter have edited a presentation of various examples of what they call sustainable solutions in their aptly entitled book “Sustainable Solutions” (2001). The degree of sustainability and change varies, but many approaches and examples are used to show that design is widespread and divergent. However, there appears to be a lack of methodology on the third and fourth levels.

This thesis will focus on design for sustainability as an activity involving a system view where products and services are important cornerstones, focusing on non-material values as well as material values, but most importantly on transdisciplinary development and communication leading to new solutions that answer fundamental human needs based on sustainable principles.

1.5 The research perspective

1.5.1. Normative research within the phenomenological tradition

This research is a normative study in terms of the research aim; to improve existing design methodology in a direction that is seen as favourable within a set of chosen values.

The hermeneutic tradition and view of research explores the understanding of human signs to understand our inner life. Martin Heidegger defines phenomenology as the *way we understand* ourselves and our surroundings (Gullvåg 1990). We always operate within a horizon of understanding which affects our experiences, thoughts and actions. In every wish to develop our understanding we will be operating within our own personal horizon. This will affect the results and conclusions of our research. This paradigm of theory of recognition, phenomenological research, originates from the social sciences and has later been found to have great value in the humanities.

In this thesis phenomenology is not explicitly represented as research methodology. The dissertation is based on a combination of analytically focused and synthetic-holistic approaches (Alain Findeli 1995). While the world is analyzed and observed, constant reflection is puzzling the pieces together into a synthesis. Phenomenology here is the scientific worldview which is considered useful in this research since it includes both material and non-material issues in terms of revealing *an understanding of relationships* and an evolution and movement in knowledge building (see Chapter 4.2).

1.5.2 Inductive research in the model of flexible design research

The phenomenological tradition is characterized by *inductive* research. An *inductive* research approach presents research questions or themes rather than hypotheses. The themes or questions are based on assumptions within a larger picture of understanding and shall lead to new reflections and further understanding in the effort to try to answer the questions. *Deductive* approaches operate with axioms or rather hypotheses which should be proven wrong, and if they can not be proven wrong they turn into sentences of truth, axioms.

Colin Robson (2002) distinguishes between two different research designs. A flexible research design is characterized by the modification of the research questions as the data collection and analysis proceeds. In fixed designed research it is necessary to have the questions and priorities early in the process, where the pilot phase is only for fine-tuning the questions.

Fixed design research may have an experimental strategy where effects are measured after manipulating one or more variables to a situation. The details of the research design are then fully pre-specified before the main data collection begins. The non-experimental strategy in fixed design does not manipulate the object of the study. Typical in both strategies is a pilot phase where the changes are made if necessary before the pre-specification is made.

My thesis is *inductive,* based on the model of *flexible design research* (see Chapter 4), which means that the research questions evolve during the initial phases of research rather than being fixed at the very beginning of the work. A focus is chosen and then a pilot study delivers feedback that helps in the fine-tuning of the final research questions. There are no hypotheses, but assertions from theory that the questions arise from. This is a typical research approach for *qualitative studies*. For this research, a pilot study focusing on the factor 10 concept was followed from its initiation in April 1999 to the summer of 2001 (pre-project), and as a main study from the fall of 2001 to 2002, summarised at a seminar in the summer of 2003 (see Chapter 5).

1.5.3. The evolvement of the research questions

The research questions at the early stage of the thesis work in the spring of 2000 were focused on product service systems as value carriers and their possibility of supporting sustainable development through provided experiences, regarded as “total” by the customer. This was seen as an implicit approach within the factor 10 concept.

In February 2001, the questions had evolved, and the focus on factor 10 design development became more explicit. The issues concerning user experiences now have a lower profile and are replaced to a higher degree *by the term of needs* of an individual and societal nature. The business relation to the design process was also more eminent (Table 1, in Appendix I).

A third and much more simplified version of the research questions was presented for discussion in March 2001. The focus on services was toned down and not explicitly mentioned in the questions. *System design* was used as a replacement term with intention of covering both product service systems and systems of products which did not necessarily include services. The research questions focused on the design methodology towards factor 10 solutions, criteria for sustainable solutions and the designer's role in inter-corporate design teams.

The research questions where finally constructed after the pilot study was closed in the autumn of 2002 (presented in Chapter 4). A case study was then chosen (presented in Chapter 5) as a relevant project for comparison and as a complimentary study to the methodology executed in the pilot phase.

1.6 The final questions for further research, aims and objectives

Aims

- To create a methodology for development of holistic sustainable solutions.
  Alter the mindset from product-to-human activity thinking, integrating human needs in a long-term sustainable perspective.
- To develop an integrated tool for designers and the design team, to guide and evaluate their concept development in an early phase of the design process as they move towards sustainable solutions.

Objectives

- Explore holistic design thinking and ideas of sustainability through eco-philosophy
- Explore the existing factor 10 concept and research
- Capture the pragmatic design approach in practice

The final research questions have two main perspectives:

Assertions (see Chapters 2 and 3 for more detailed presentation):
The need for a holistic and concrete approach
A1 To create significant changes in the direction of a society with sustainable patterns, human behaviour and culture must be part of the guidelines for new design and system thinking. Designing the premises for a user-activity is as important as designing the product and system solution itself.

By focusing on the user activity and the total user experience, the design process will call for deliveries which are represented by various companies in an integrated total solution. Factor 10 design solutions require developer, company and organization co-operation to arrive at solutions on this system level that lead to intensive reduction of material and energy consumption. This invites designers representing companies and organizations to work in larger collaborative ventures to achieve holistic results. In this perspective the design process is an important part of the strategic thinking in the involved corporations.

Research questions

Q1 How can product and system concepts be designed to promote a factor 10 development?

> **Q1a** Can connected functions and experiences serving the end-user be the starting point of a co-operation between the main stakeholders, rather than the products themselves?
> **Q1b** How can a new methodology include the long-term perspective and the short-term steps coordinated in the development of new concepts, and in the setting of a company and/or organization?

Assertions (see Chapters 2 and 3 for more detailed presentation)*:*
The need for early concept evaluation of sustainability performance

A2 The qualitative characteristics of the solution are also of major importance in reducing toxic emissions, sustainable use of materials and energy and non-material perspectives in design, such as social and ethical values. These issues must be integrated in the early phases of the design process to complement the available quantitative information and analyses. If we are to design sustainable solutions, developers must also include more qualitative prime movers from human instincts, motivation, acceptance and needs; along with prime movers from the economic and technological climate embracing the product and system concept building. Ecological problems depend on solutions resulting from a change in human- thinking.

Research questions

Q2 How can design concepts be evaluated in the early phases of the design process with respect to their ability to contribute to future development in a factor 10 direction?

> **Q2a** How are the different principles of sustainability, guidelines and criteria defined for the new concepts?
>
> **Q2b** How will the principles of sustainability, guidelines and criteria enter the design process to promote and evaluate future factor 10 solutions?

1.7 Thesis structure

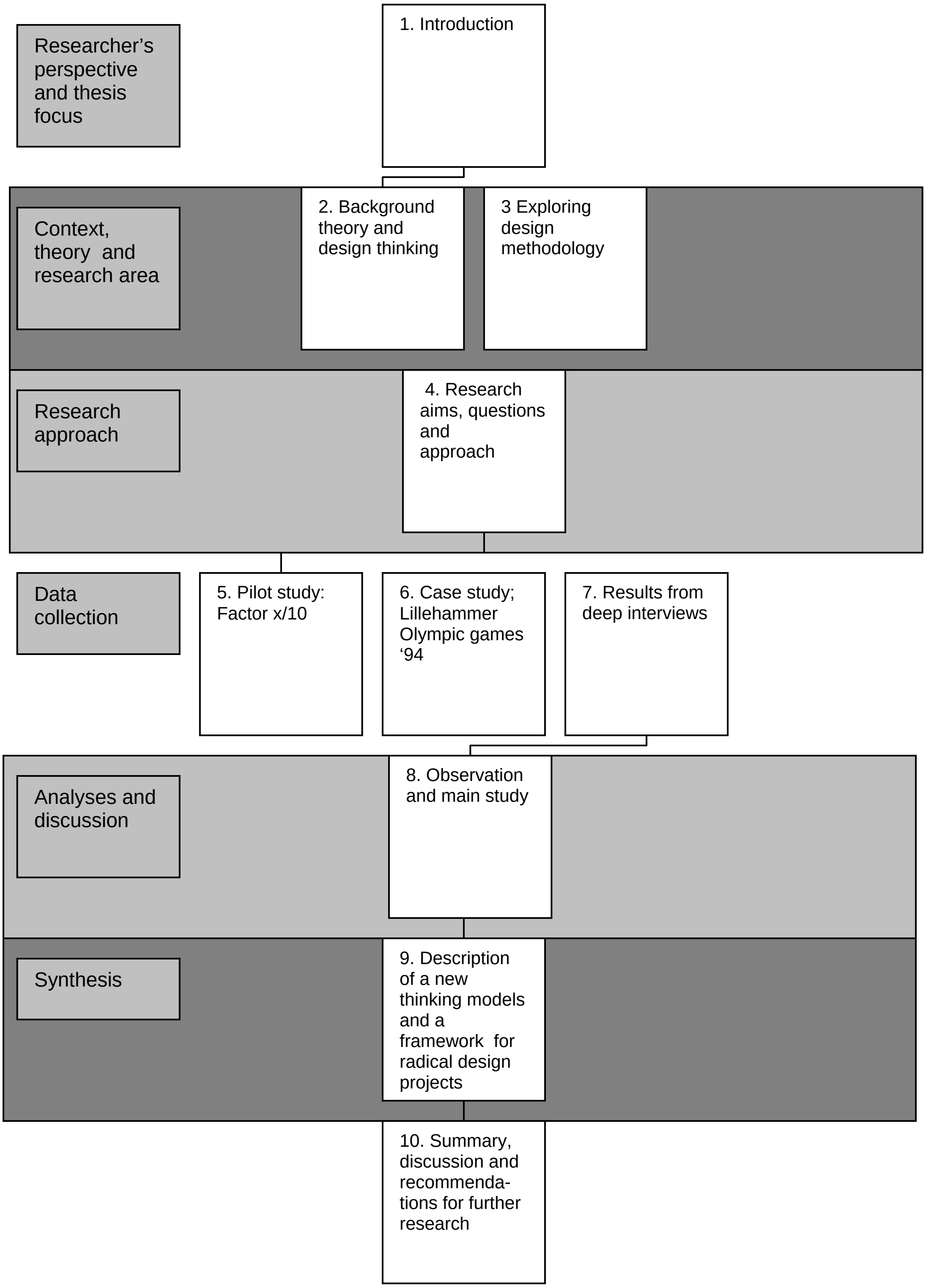


Figure 8 The thesis structure.

1.7.1 Context and research area

Chapter 2 presents environmental-challenges theory in discussions on sustainability in a material perspective and presents a philosophical examination of sustainable principles based on eco-philosophy. The chapter also describes relevant design initiatives representing awareness of conscious choices of values in the design process. *Chapter 3* provides an overview of existing design methodologies, explored from a global, system and product perspective. Furthermore, the characteristics of the initial phases of a design process are presented along with the relevance of sustainability to design. Finally the research areas are discussed as a consequence of the described context, theory and methodology.

1.7.2 Research approach

Chapter 4 presents the final research questions and appropriate research approach and methodology. The last section presents the general theory of design research, in addition to the phenomenological tradition this thesis employs.

1.7.3 Data collection

Chapter 5 describes the factor x/4/10 pilot study, which both experiments with a new factor 10 design methodology and reveals the focus for further research.

Chapter 6 presents the case study: the design process for the visual profile of the Olympic Winter Games in Lillehammer 1994. This case study represents a completed project of an advanced nature, where the design process was founded on an overarching vision in a system perspective that is manifested in small products, service concepts and retailing. The knowledge from this case study is seen as important in relation to the contrast between short-term steps and long-term thinking. *Chapter 7* provides a summary of the deep interviews with participants in the pilot study and the Olympic Games' design process. The summary is structured by the key-words used in the coding of the interview transcriptions. The coding is constructed with the aim of finding detailed information which is important for successful radical design projects.

1.7.4 Analyses and discussion

The final sections of Chapters 5, 6 and 7 provide the main findings in the empirical studies. Chapter 8 makes further observations and presents the main study of the material.

1.7.5 Synthesis and summary

Chapter 9 adapts the new knowledge in the form of proposals for value models and a framework for radical design projects. Finally, *Chapter 10* concludes the thesis with a summary, a brief discussion and recommendations for further research. (*Figure 8*).

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2.0 Background and theory

This chapter places the thesis within a tradition of design, which continuously is changing align with the changes in society in general (Margolin 1998). The discussed topics in chapter 1, such as the definition of industrial design, are thus evolving, and the search for meaning in design is influenced by the paradigm the thinking and planning is placed within. To integrate a message, expression or company believes in the design solutions is a part of culture and cultivation of technology in society. This places the designing activity in relation to artistic work but also to political and social initiatives. The caring of nature and reflection of human activity and priorities is therefore not alien to the designer from this tradition. This chapter will present some initiatives based on conscious and explicit expressed non-material values manifested in industrial design. The material solutions are value carriers and problem solvers. Industrial design is usually performed in the setting of mass-production, marketing and sales. The business strategies frame the design activities. In this perspective design is used as a strategic tool to achieve specific goals concerning company profile, branding, and market shares and of course good products and systems. The initial sections of this chapter will introduce some of the environmental problems that are caused by products themselves, the consumption and use of them and the economic system; both in a global and local perspective. Then to indicate some directions for new development, theory concerning sustainable principles and various approaches towards sustainability is . On this scene it may appear rather naïve to promote new suggestions from a designer's perspective, which are meant to contribute to radical development and changes in sustainable directions. However, to support the somehow pre-mature philosophical discussion also found in this chapter, the work is continued in the light of Margaret Mead's (1901-1978) quote:

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed it is the only thing that ever has."

2.1 Products designed with environmental impact

2.1.1 Ecological challenges

The issues concerning environmental impact are of a wide range. Activities that threaten the biological diversity and non-renewable natural resources may be consequences as of poverty, greed, lack of knowledge and other numerous reasons. The solutions to the actual problems must therefore be seen in the light of economic, social and ecological dimensions, namely where the reasons appear.

In the methodological framework of Life Cycle Assessment (LCA), the main damages to the environment as a consequence of human activity, are divided in three major categories; exploitation and destruction of resources, human health impacts and ecological impacts (Lindfors et al 1995). The three categories are further divided in new categories again with deeper detailing (Table 1).

Impact category
1'. Resources - Energy and materials
2. Resources - Water
3. Resources - Land (including wetlands)
4''. Human health - Toxicological impacts (excluding work environment)
5''. Human health - Non-toxicological impacts (excluding work environment)
6''. Human health impacts in work environment
7. Global warming
8. Depletion of stratospheric ozone
9. Acidification
10. Eutrophication
11. Photo-oxidant formation
12. Ecotoxicological impacts
13'''. Habitat alterations and impacts on biological diversity
14''''. Inflows which are not traced back to the system boundary between the technical system and nature.
15''''. Outflows which are not followed to the system boundary between the technical system and nature.

Table 1 Impact categories in LCA. The impact categories can be further divided into sub-categories (Lindfors et al 1995).

2.1.2 Human social challenges

The State of the World 2004 (Brown 2004) is focusing on the increase in material consumption in the Western World that has grown four folded since 1960 and till today, while the experience of life quality and happiness on the individual level is the same since 1954.

Global comparisons for living standards

The highest economic living standard per capita in the world is found in Luxemburg with 45 100$ per capita divided from the GDP. Norway is fourth on the ranking with 34 310 $ pr capita. The lowest economic living standard is found in Ethiopia and Myanmar with 100 $ per capita divided from their GDP. (The Economist, World in Figures 2001). In concern of purchasing power (USA= 100) in comparison with GDP, Luxemburg has 125,5 per head and Norway is on fourth place with 89.6 per capita. The lowest country is Sierra Leone with 1,5 per head. The quality of life is defined by a Human development Index from a UN Development Programme. Indicators which are evaluated are average schooling, adult literacy, life expectancy and income level. Countries scoring from 100-80 are considered to have have high human development, from 79-50 have medium human development, and below 50 have low human development. The numbers and indicators reflect a major inequity in use of resources among the world population (Figure 9). As mentioned in chapter 1.1, equity in material life standard on the Western World level (including Japan) will request at least four Globes.

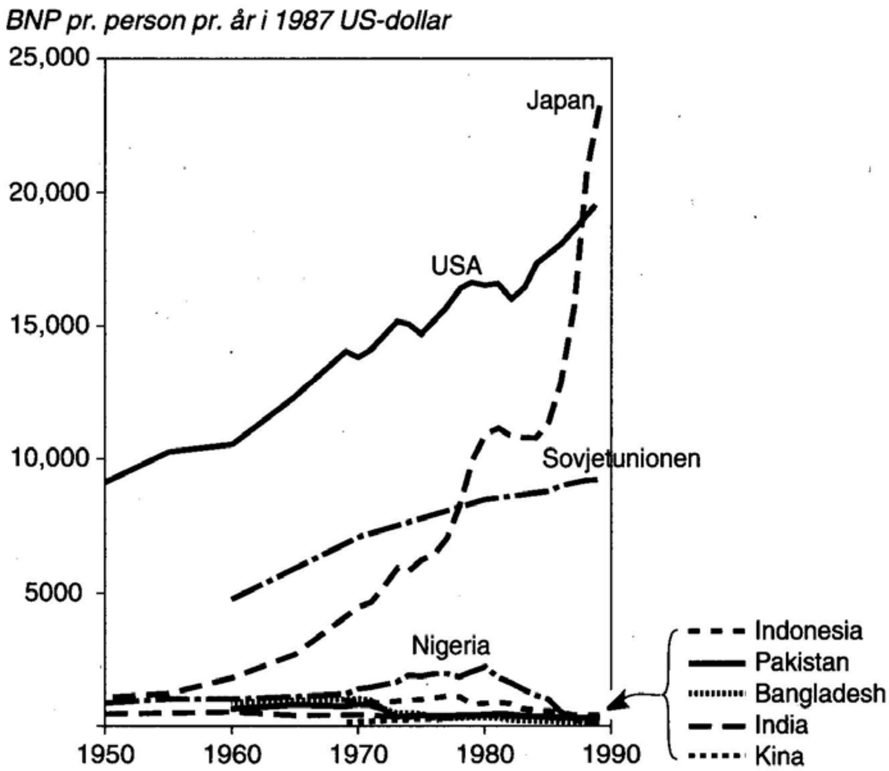


Figure 9 The BNP per person per year in a selected set of countries (Meadows et al 1992).

Consumption
One person in a large household (4 or more) uses only 60% of the amount of materials and only 40% of the energy used by a person who lives alone. In UK the population has increased by 11% from 1961 to 2001. The households have increased by almost 50% in the same period. The average household size has dropped from 3,1 to 2,3 persons (INCPEN 2001).
This indicates that the family situation and personal priorities play a key factor in the consumption per capita. The economic freedom is also promoting freedom of choosing different and maybe more individual lifestyles.

The following table (Table 2) is presenting the average UK household's environmental impact (2 grown ups and 2 children) measured in energy; GigaJoules/household/year (INCPEN 2001)

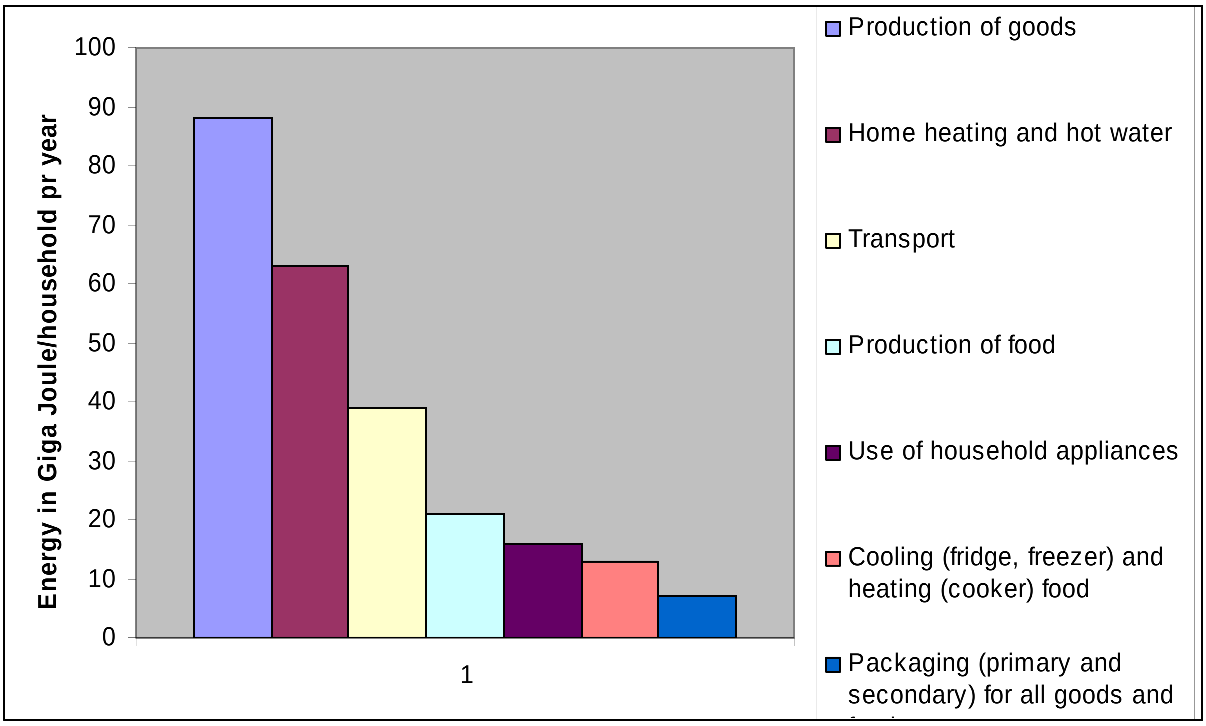


Table 2 The average UK household's environmental impact (2 grown ups and 2 children) measured in energy; GigaJoules/household/year (INCPEN 2001).

In the British study the production of goods is found as the largest impact in terms of energy consumption per household, then follows house heating and hot water.
A research team at Ôstfold Research Center (STØ) evaluated the life long consumption and environmental impact in terms of CO_2 emissions of an average Norwegian (male)(Table 3)(Rønning et. al 1999). The heating and electricity is based on Norwegian hydro power and oil. The person in the study is fictive, but is defined as married and father to two children in his grown up life.
The results during his 80 years of life, is accounted in kilograms of CO_2. Transportation was found as the outstanding activity for environmental impact in these analyses. Production of goods (here clothes and shoes) and heat of housing and hot water have about only the half of the outlet of CO_2 compared to the transportation.

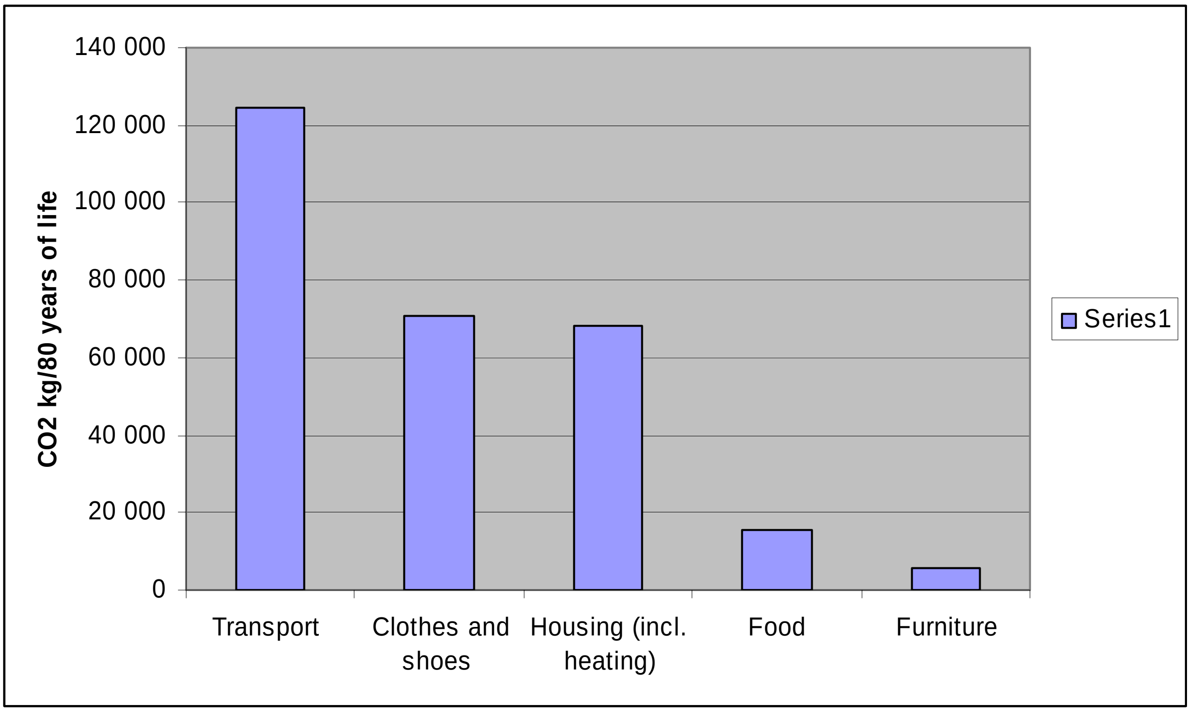


Table 3 Emission of kg CO2 per 80 years of life, counted in on year (Rønning et al 1999).

The two different assessments are probably based on different patterns of consumption and are based on different values, namely consumption of energy (INCPEN) and CO2 emissions (STØ) and the uncertainty in the data material is high. The intention behind the studies is also different, however, it can be useful to place the issues of environmental impact to the activities in life and find the dimensions of importance in terms of change and new solutions. In both studies the transportation is an important source of emissions (CO2 from fossil fuels) and energy consumption.

Economy

The private economic picture is witnessing a change from the strugle for purchase of food and basic needs to enjoying the welfare in spare time and comfortable surroundings.
In Norway an avera.ge household is spending 13% of the income on leisure and 11,4 % on food (Table 4)(SSB 2003).

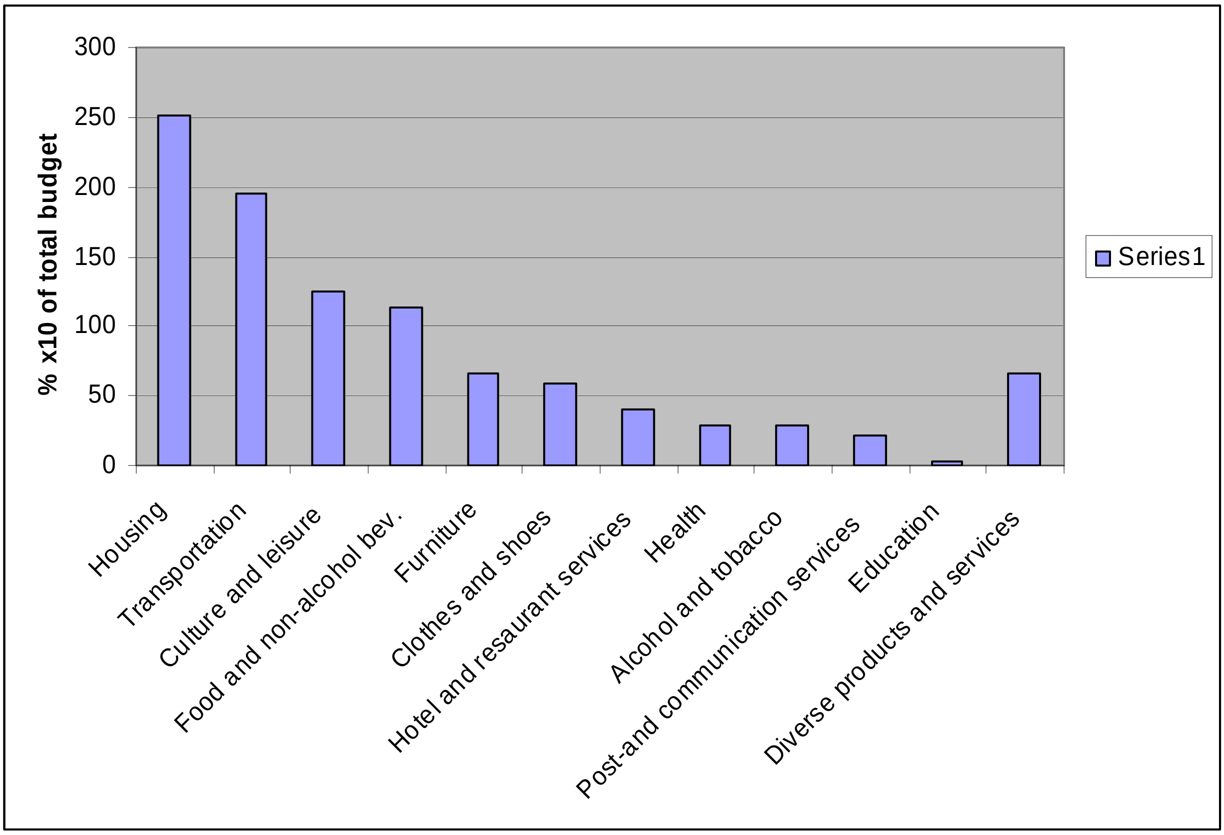


Table 4 The pattern of private economic activity per year based on the average Norwegian income (SSB 2003).

The average income has increased by about 75% from 1989 to 2002 (From 147 000 NOK (Aschehoug, Gyldendahl 1992) to 260 000 NOK (SSB 2003)). In this period (1992-2002) the amount of household waste pr. person has increased by 49,4 %, from 237 kg to 354 kg pr. person.
The challenges in this picture are not only pointing to the appropriate design of products and systems life cycles, but also a total reduction in the consumption of material products and energy. The economic framework is obviously affecting the consumption and behaviour pattern. These are complex mechanisms, which go beyond the area of a company and designer's activity.

Waste

Weizsäcker at al (1997) points to the flow of materials in a production process, and the fact that 93% in general of the material flow in industrial processes ends as waste along the process. Only 7 % material ends into the final product. Weizâcker believes in technological optimization of production processes, new practice and introduction of new technological solutions.

The total waste amount for Norway in 1999 is divided between the industry, private households, service activities, and the building sector (Table 5).

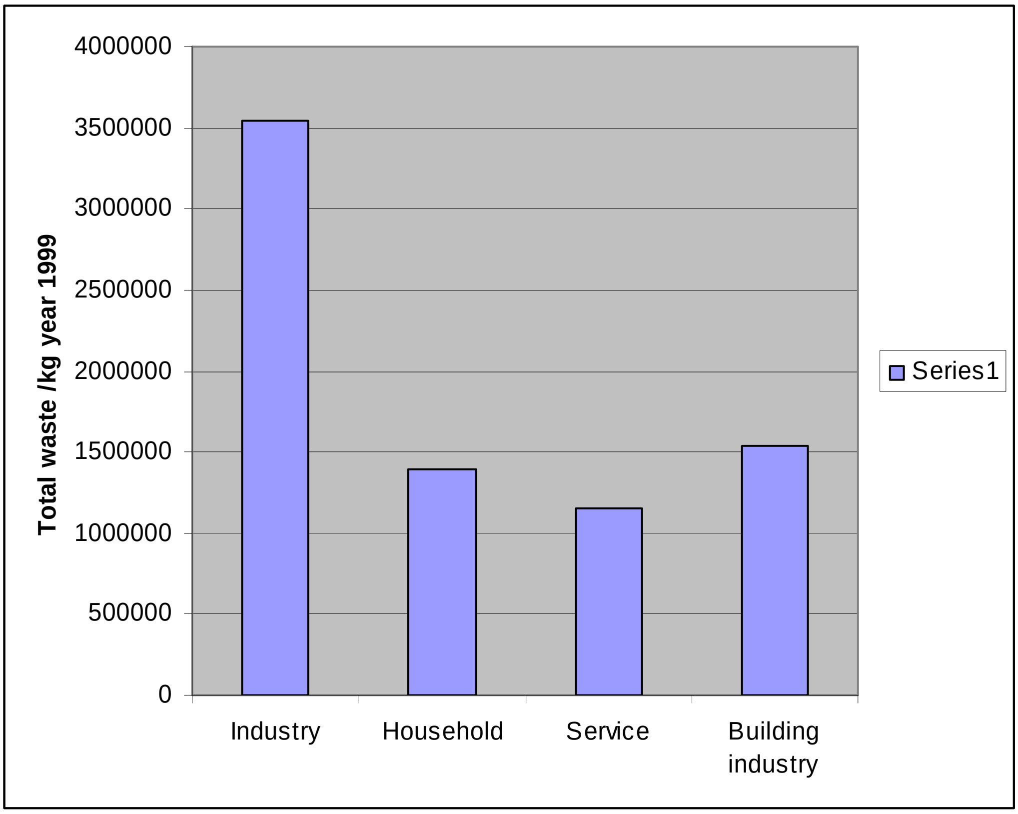


Table 5 Total 8 291' kg tons waste amount in Norway for the four areas in 1999. (SSB 2003).

In the environmental discussion there are several stakeholders who contribute to the increasing amounts of resource use and waste. Among private households, service, and building industry, the figures show that industry is a major contributor.

2.2 The premises for ecological and material sustainability

In the article "The limits of technological solutions to sustainable development" M.H Hueseman (2003) describes the material and technological challenges that are faced in terms of sustainable development. Hueseman points to four different reasons for why technological solutions have their limits and how the economic systems are of a non-sustainable character today.

The evaluations and accountings presented by Hueseman show that the strategy of eco-efficiency (see ch. 1.1) alone will not bring about a transition to a sustainable society.

The four reasons are:

- It will be extremely difficult to switch to an industrial and economic system based solely on renewable resources. The western industrial society is based on exploitation of non-renewables and 100% recycling of this material is impossible.

- All energy should be derived from the sun, directly or indirectly. However with the present high energy consumption, serious and unavoidable environmental impact will also occur by use of this energy source.

- Further, the second law of thermodynamics (Formel 1) reveals that all industrial and economic activity have unavoidable negative environmental consequences.

- The technological improvements only delay the onset of negative consequences that as a result will have increased in severity, and thereby reduce the freedom to choose satisfying solutions. Growth in population and consumption must therefore be constraint in parallel with introduction of new solutions.

Hueseman is referring to “the weak and strong sustainability” (see also ch. 1.2.). His argument concludes that a strong sustainability strategy is necessary to ensure that current economic activities can continue without serious interruptions at least in theory ad infinitum.

“Strong sustainability” is, however, a non-compromising approach in terms of 1) introducing renewable raw materials and energy at rates that do not exceed the regenerative capability of the respective eco-system or cause other disruptive environmental side effects, 2) Waste can only be released into the environment at the rate which is compatible with the assimilation capacity of the respective eco-system (Hueseman refers to a number of sources supporting this view).

“Weak sustainability” is still including some materials from the lithosphere, such as metals and minerals. A depletion of natural resources is accepted through the building and increase of human capital (aggregate stock of manufactured goods). Human capital can however, not indefinitely substitute for the for ever declining stock of natural resources.

Industrial ecology

Industrial ecology (further discussed in 2.7.1) is introducing the idea of chains in the industrial systems, whereas waste from one process is “food” in the next production. This may concern materials, fluids and energy. Kalundborg in Denmark is the classic and initial example of symbioses between different industry located at the same site. This specific chain of resources and sharing of facilities is based on economic drivers and has later been evaluated as an industrial ecological model.

Hueseman is, however, questioning if these technological steps approach the desired goals of sustainability. When it comes to recycling of non-renewables, he is presenting a table (Ayres 1994), where materials are classified in three categories of recyclables. Category I contains materials which are both technologically and economically feasible for recycling, such as industrial metals and catalysts. The recycling of category II which is technologically possible but not economically beneficial so far is; packaging, refrigerants, solvents and more. Category III is presenting neither technological nor economical feasible materials in terms of recycling. Unfortunately this is the largest category of non-renewables, and involves for example lead in paint, phosphorus in fertilizer, and rubber powder abraded from car tires.

The energy, which is need for purification of nature increases drastically with decreasing material concentration in the environment. Even if the energy used for this type of process was renewable, the energy needed will be enormous and causing both environmental impact as well and economic costs. Major environmental disruption is however caused by some dissipated materials, even in low concentration.

According to the second law of thermodynamics (Formel 1), energy ($\triangle E$) is used to decrease the entropy
($\triangle S$)(increase order) of a system at temperature T [K] according to (Faber et.al 1995, in Hueseman 2003):

$$\triangle E = - T \triangle S$$

Formel 1 Second law of thermodynamics.

The solar energy is adopted by the photosynthesis, which generates biomass and functions as fuel for the entire biosphere. Renewable resources including solar energy can only be harvested at rates that do not exceed the respective regeneration rates (Figure 10).

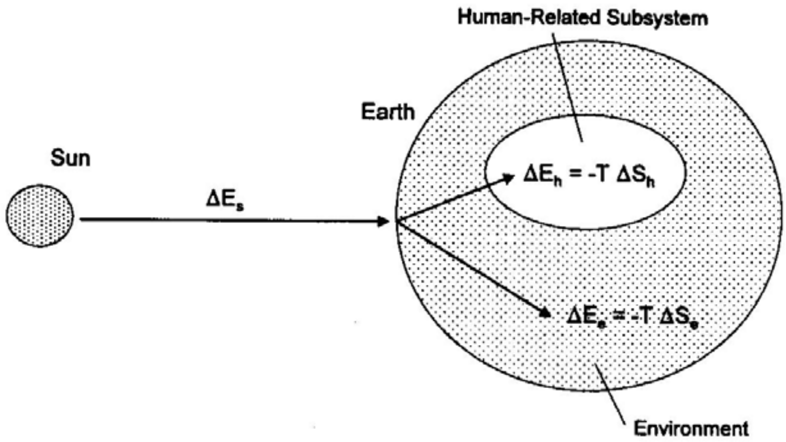


Figure 10 Solar energy must be harvested in appropriate rates (Hueseman 2003).

Hueseman is illustrating the technosphere as a subsystem in the environmental system (Figure 11). The energy consumption in the technological activity is transformed, taken from the biosphere, or indirectly from fossil fuels.
The second law of thermodynamics describes how it is possible to increase the order within a small subsystem, however, it will be at the expense of creating more disorder in the rest of the system (closed systems). While the human being is creating “order” in his own subsystem (technosphere), the civilization is creating disorder in the natural system. On the other hand, the human is a part of the natural system in itself, so the consequences on nature will affect the human being, for example health. The entropy increase is the measurement for pollution.

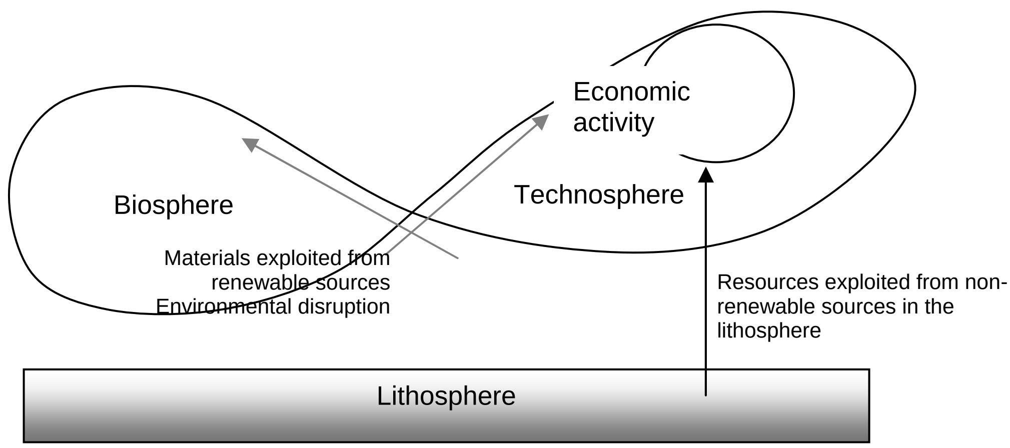


Figure 11 Economic activity leading to environmental disruption. Hueseman is referred to the economist N Georgesu – Roegen (1971). He points to the connection between economic activity and environmental disruption. The consequence of this theory is that industrial and economic impact never can be reduced to zero.

The Factor 2 reduction in consumption per capita (50% reduction pr. Western dweller) is by different researchers claimed to be reachable in relatively short time (Weizsâcker 1997, Jansen 1997, Weaver 2000). Factor 10 (90% reduction pr. Capita), which is defended by some researchers as a required reduction to achieve sustainability, is not achieved by the means of today. Research and development is required, as mentioned by Hueseman.

Factor 2 and 2,5 % economic growth will delay the process for 25 years. Then because of population growth and need for material goods and energy, the environmental impact will increase to the starting point (Figure 12).

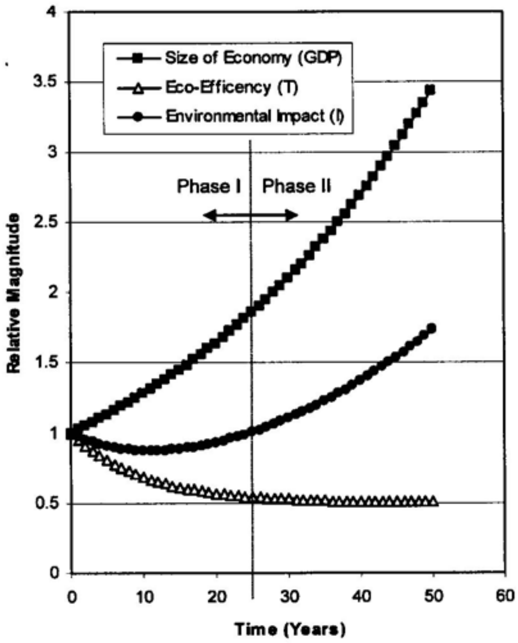


Figure 12 If the products are improved by an eco-efficiency of factor 2, the gain in lower environmental impact will be lost in the increase of GNP (2,5 %) within 25 years (Hueseman 2003).

Eco-efficiency would be effective if the size of the economy had been stable in the long term. Technology and innovation has, however, been the means for the opposite, namely economic growth. The rebound effect of decreased prices through leaner and more efficient production is the increased use and consumption. As stated by Hueseman, it is clear though that the modification of greed and procreation is an ethical and not a technological issue.

Closing the material cycles, promoting use of renewable materials and energy, and reducing toxic pollution of all kinds to air, water and soil are the major issues in industrial ecology. These issues additionally involve a numerous of stakeholders and are requiring tools and abilities for communication.

Huesman leaves the human population with the choice of value priority concerning what type of sustainability endpoint is aimed for. What type of world we want to create and live in. He refers to Daly who presents a choice between the anthropocentric or biocentric values, depending on what surroundings and what lifestyles wanted. Other views than the antropocentric, such as the biocentric view, will include the care of all living and evaluate the human quality of life in connection with the well-being of nature (Further discussed in 2.3.2). Hueseman comments that improvement in eco-efficiency is unable to deal with these vital matters.

2.3 The premises for social and spiritual sustainability

2.3.1 The nine Fundamental human needs (Max-Neef 1987)

The quality of life is often usually measured and experienced in relation to the satisfaction of fundamental needs. The definition of these needs have been discussed by e.g. Maslow (1977) but also others like Manfred Max –Neef (1987/1991)and Sören Ventegodt (1998).

Manfred Max-Neef is a Chilean economist, who works for the Centre for Development Alternatives in Chile. He is criticising the conventional models, which have brought both social and economic disasters to many of the developing countries.
The nine human fundamental needs are presented as nine specific. These nine needs appear with characters that can divide them into material and non-material needs.
The material needs are basically: Subsistence and Protection; and the non-material ones are: Affection, Understanding, Participation, Leisure, Creation**,** Identity and Freedom. However, all needs

can at least partly be *satisfied* by both material and non-material *satisfiers.* Max-Neef describes the needs existing in 4 different states: being, having, doing, interacting.

This creates a matrix for examples of *satisfiers* answering to the needs and the state they are in (Table 6). Max-Neef is categorizing the satisfiers as violators or destroyers, pseudo satisfiers, inhibiting satisfiers, singular satisfiers or synergic satisfiers. He underlines, that some satisfiers are destroying the possibility of satisfying other needs (e.g. war).There are other satisfiers which support additional needs (e.g. educational games).

The interesting characteristic to the fundamental needs is their independence of culture, time and place and the stable amount. However, the satisfiers do vary and are infinite in numbers. So are the "wants". Max-Neef is proclaiming a non-hierarchic relationship between the different needs (apart from the basic need for survival), still they are interrelated and interactive.

Fundamental Human Needs	Being (qualities)	Having (things)	Doing (actions)	Interacting (settings)
subsistence	physical and mental health	food, shelter, work	feed, clothe, rest, work	living environment, social setting
protection	care, adaptability autonomy	social security, health systems, work	co-operate, plan, take of, help	social environment, dwelling
affection	respect, sense of humour, generosity, sensuality	friendships, family, relationships with nature	share, take care of, make love, express emotions	privacy, intimate spaces of togetherness
understanding	critical capacity, curiosity, intuition	literatures, teachers, policies, educational	analyse, study, meditate, investigate	schools, families, universities, communities
participation	receptiveness, dedication, sense of humour	responsibilities, duties, work, rights	co-operate, dissent, express opinions	associations, parties, churches, neighbourhoods
leisure	imagination, tranquillity, spontaneity	games, parties, peace of mind	day-dream, remember, relax, have fun	landscapes, intimates spaces, places to be alone
creation	imagination, boldness, inventiveness, curiosity	abilities, skills, work, techniques	invent, build, design, work, compose, interpret	spaces for expression, workshops, audiences
identity	sense of belonging, self-esteem, consistency	language, religions, work, customs, values, norms	get to know oneself, grow, commit oneself	places one belongs to, everyday settings
freedom	autonomy, passion, self-esteem, open-mindedness	equal rights	dissent, choose, run risks, develop awareness	anywhere

Source: Max-Neef et al, 1987 summarised at http://www.rainforestinfo.org.au/background/maxneef.htm [26]

Table 6 The table of needs and satisfiers are adopted by designers and developers as guidelines in the design process. This table is borrowed from Alastair Fuad-Luke (2002) in his article introducing "slow design". Fuad-Luke has borrowed the table from the Rainforestinfo internetsite, where the material is summarized by Kath Fisher.

Max-Neef and his collegues are using this presepctive on needs in methodology, which is focusing on small groups or community-based processes that have the time and possibility to go deeper into the community situation and reveal critical conditions and possibly find pathways, leading to action at the local economic level.

Connection between quality of life and access to nature
The research by “Forskningscenter for livskvalitet” (“Research center for life quality”)and “Forskningscentret for skov og landskap” (“ The research center for forrest and landscape”) (Ventegodt 1998) concluded in their report that the majority of the Danish pouplation would give the priority of reconcile the forests in different areas in Denmark. They believe this would contribute to an experience of higher life quality. To the Danish majority, life quality is strongly related to the access to forest and nature in general.

Ventegodt (1998) promoted three perspectives when quality if life is to be measured. These are the subjective, the objective and the existential perspectives. The three perspectives are represented by the superficial state of well-feeling, the physical belongings/ surroundings and the deeper feelings and experience of life.

The three perspectives can be defined more concrete:
The subjective:

- well-being/feeling (how do you do? fine, thank you!)
- satisfied with own life situation (adapting to situation or changing the situation)
- happiness (deeper feeling of great joy)

The existential:

- satisfaction of needs (ex. Maslow, Max-Neef)
- time spent with family, work and leisure
- content related to relationships (one self, partner, children, friends, society and nature)
- self realisation/development – revealing life (livsutfoldelse)

The objective:

- physical parameters (income, marital status, health profile etc.)

Living with products and artificial surroundings
Tonkinvise (2002) discusses in his article how a totally change in attitude towards the technology and use of products is needed.To repair, maintain and live with the change of a product has become a strange and scary thought to many people in the developed part of the world. Repairment is often more expensive than purchasing a new object, and maintenance is often even impossible because of the design and production of the product.If this is reintroduced by the designers it can influence people exposed to the new thinking through sustainable service systems.

The needs of different character and the experienced quality of life can be supported and promoted by artifical solutions based on acknowledgement of the human essence. Papanek (in: The idea of design, Margolin 1995) is referring to Aristotle and the four desires which make human seek urban centers or human communities: Conviviality, religiousity, intellectual growth and politics. All these desires are answered by the restaurants or theatre, the churches and temples, the library and museums and the Town Hall. These functions are then surrounding a market place for trade.

The liberal consumerism is based on a superficial interrelationship between humans and the things they make and buy. The traditional eco-design is also trapped in this frame of economy, based on rapid consumption and production (Tonkinwise 2002). What design mostly contributes with in the Western World today is the news. Then we are entering the fashion world. It is said that products express your identity. Well, is this really true? Why is your identity changing along with the fashion news? According to Max-Neef’s matrix, fashion is a pseudo satisfiers, it is stimulating a false sense of satisfaction. (Dewberry 2003). There may be a second agenda. The products express that you are au jour or even slightly ahead of the trend. You are informed about the products being produced and are able to buy the “right” things. Why is this very important to many people and an increasing amount of people? It has always given a certain status among most people to expose symbols to the society about their economic capacity and at the same time being approved by the people they would like to be identified with (Linn 1993). The satisfier of belonging to a group of people is supporting the need for an identity.

It may be asked if the economic drivers and ubiquitous marketing is a threat towards the individual believe that there are actually interesting and meaningful activities and experiences which can be enjoined for free(Tonkinwise 2002), e.g. library, hitchhiking, playing games and telling stories.

2.3.2 Values and ethics for sustainability

" If the product can reach the user's actual needs, support the user's identity and be carrier of spiritual and non-material values, each of us might not need as many products or exchange them as often as we do today, as substitution for missing values (Walker 1999)(Wigum 1996)."
(Wigum 2000)

This section of the chapter is stepping into the world of philosophy assisted by Dr. phil. Martina Maria Keitsch (NTNU) who has been supervising the candidate in this material which emerges from eco-philosophy and ethics, towards industrial design and it's relation to human activity and sustainability.

In order reflect a sustainable co-existence of society and nature, we have to ask questions such as: How deeply reach the ecological problems in the mind of human? Is it possible to create organised systems based on mass production and modern digital technology, leading to new sustainable life styles and societies in balance with nature? What values should we agree upon our systems and cultures to be able to create a sustainable future? Where is this insight, which is needed to be found? Finally, what do humans need to be peaceful and excited about life?

To discuss these questions about sustainability, three philosophers, Arne Naess, Martin Heidegger and Hans Jonas are used as refrences from this particular point of view. To enter the debate, the evolution of ethics and how the ethical perspective influences important priorities in society, is briefly introduced. This section continues with a reflection on the human existence, the importance of immediate experiences and the attention towards nature, fellow beings and oneself to find inspiration and understanding about the connections between human and nature. How is this related to products and mass production? Some principles will be discussed. In the following section some practical examples from industrial design activity are used to illustrate some of the possible consequences of the implementation of these ecological and ethical principles within the design of product systems.

The research questions are practical approaches towards this overall discussion of sustainability and human made things. The questions will therefore relate the philosophical argumentation to the existing knowledge and practice for business activity and designing.
Principles, guidelines and criteria are terms which will be discussed further in chapter 8 and 9 and then related to the term sustainability, for next to be evaluated in a design process, and then the actual question of how to define these parameters for new concepts (see research question Q2a and Q2b ch. 4.4).

Development of ethical consciousness in the Western traditions

Human history tells about the Homo sapiens trying to survive in tough natural conditions. The humankind has fought against themselves, each other, things and systems they have created, and against nature. Part of survival is defeating the threatening in nature, first with primitive tools and weapons, later more complex, with technology and systems controlling the experienced danger. When the primal needs are covered, the society and single individuals are ambitious to create comfortable conditions of material substance. Thereby more and more individuals of the human race are caught in so called productivity and search for high standard living. Human labour has become organised in new ways. Technology is defined as machines and tools that are more efficient than human working power that is able to repeat production processes in masses- for mass production.

The ecological threats that are documented, experienced and expected are at the first glance rooted in use of unrenewable materials, high energy consumption, fossil energy use, production processes causing high toxic emissions, critical waste treatment, all at too high concentrations and consumption mainly in the developed countries.Today, we are in the position that the humans´ own tool, once made to defend themselves and make life comfortable in a materialistic way, has become a growing threat. Being a part of nature and being depended on the gifts of nature, humanity is about to go too far, taming the wildlife, controlling the living and extracting and destroying vital resources on the earth.

Human consciousness has evolved from being mostly instinctive to egocentric and might have to progress further to an ecocentric worldview (Figure 13), which is including the perspective of ecosystems and natural conditions. Some philosophers believe that we are able to reach this world view by finding our real self, walking the path of self-realisation.

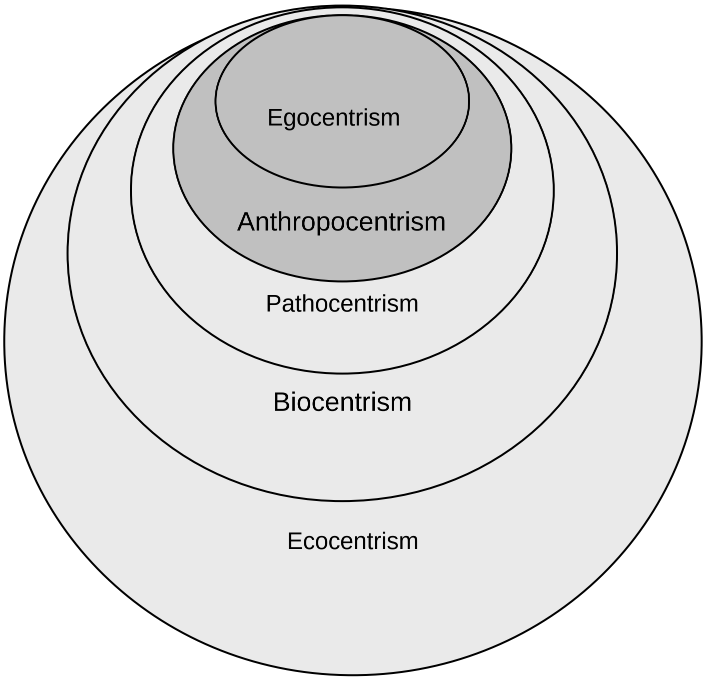


Figure 13 The world view of the human sapiens has become broader.This may increase our ability to discover and create more holistic solutions of our ecological and human problems.

Egocentrism

The most extreme point of anthropocentrism is the egocentric world view, where the values chosen are concentrated on the interests of ones own individual needs or certain needs of a group. The conservation of nature will then be relevant in the way the single individual or group is dependent on the resources of nature.

Anthropocentrism

In the view of anthropocentrism nature has no intrinsic value but is there to satisfy the needs of humankind via utilisation. Nature is there to give the human an environment for survival. Nature can be observed and experienced through the senses of human. From this point of view the human can place himself beside nature in the wish of considering its phenomena, without self being a part of nature. Nature has instrumental value and is only useful in the sense it can reply to some defined human needs. The single species have no necessary value in itself. Humans play the conqueror of nature, allowing themselves to decide, which species and individual creatures are to be conserved and protected.

Pathocentrism

Pathocentrism is one of the concepts in ecological ethics, which belongs to the branch of biocentrism. The concept reaches for the totality in nature, and places humankind and animals to have the same ethical rights based on the ability to feel pain and comfort. But this ethical direction also makes a compromise between the rights of the animals and the needs for nutrition of the humankind.

Biocentrism

All the living has intrinsic value independent of the relationship to the human. The perspective of biocentrism is “ the idea of nature”. The human is a member among other living beings such as plants and animal species. The holistic world view includes all natural phenomena, also the abiotic ones (e.g. water and air), in the aspect that life is depending on the total.The survival of the humankind is only possible within a nature which is intact. Here are different directions, where the most extreme points to equal value of all life (Taylor 1986 in Meffe 1997). The other more intuitive direction shows to a grading of the life value (Rolston 1988 in Meffe 1997) but with the starting point that all the living is valuable, independent of the single species utilitarian value to humans.

Ecocentrism

Ecocentrism looks for the intrinsic value of total ecological lifecycles, which all plant- and animal species cannot be divided from. This point of view makes it natural to preserve not just single threatened species, but the nutrition of these species and its total biotope as well. The entire cycles creates organisms which forces the energy and floating of material in eternal circular motion. This gives maintenance to life and continuous change. “Land ethics”(Aldo Leopold 1949 in Meffe 1997) is a result of this ethical concept. Here are larger nature areas preserved, since they are seen as having intrinsic value as the biotopes for plants and animals. The purpose of the preservation is to save the nature in totality, which is seen as formation of values in it self.

The essence of ethics

From early times all actions, which are destructive for the existence of a society, were shaped as ethical problems. This can include murder of another human being, destruction of plants or animal species with vital qualities, or pollution of drinking water and air. The ancient moral rules were related to the security and survival of a tribe as a unity. Later, when human developed their individual consciousness, ethical problems became more related to the single individuals. Today, we see a further development of ethical consciousness concerning the individual in a global perspective.
Hans Jonas (1969) describes the development of ethics: from maxims being connected with individuals towards maxims, which base on interactions between humans. Today, one human being can come into ethical conflicts with the world population via the creation of a certain kind of technology; Nature gets involved in the ethical questions as well.

Ethical concepts and the perception of what is morally responsible action is changing through time and cultures, but is always built on a common understanding and acceptance of what is best for the existence of a society. For example, the sacrifice of human life has existed in most cultures through all time, but is as a religious ritual, looked upon with disgust in the Western World today. Earlier cultures would sacrifice human life to please their gods and spirits, securing the human's vital needs. However, in the industrial developed countries of today, thousands of people are “sacrificed” in keeping up e.g. the existent infrastructure of transportation. The need of transportation and individual freedom could be satisfied by other means or improved solutions. The loss of life in car accidents might therefore be defined as much barbaric as the sacrification to the gods.

The ethical influence on cultural aspects in society

Our day by day decisions are influenced by the worldview we are taught and have grown into, consciously or unconsciously. For every individual this worldview influences in concert with other factors, such as value perceptions, cultural attitudes and ethical routines in practical daily life. These components affect the development and activities of many aspects in society. As our experience and knowledge about ourselves and the cosmos is proceeding, it demands continued moral endeavours. The constituted values can be weaken or strengthened and thus have to be adjusted according the improved perceptions and acknowledgements.The fear of ecological disruption is one reason for the changes of ethical requirements in society.

Religion

The various religions represent unlike perspectives of valuation of the human and nature concerning the awareness just mentioned. This is important in terms of how the single cultures have utilised the resources in nature. Most religions though, see the nature as a manifestation of their god’s perfection. A great difference between religions might be the faith in an immanent spirit e.g. a god or ancestors in nature, and the striving for enlightenment from a divine source divided from nature. This can influence how the cultures' view the human role related to nature, for example human as advocates, or as proprietors, or as housekeepers (Luther).

Science

The western scientific methods are based on the view that the human is standing “outside”, observing nature through an objective view. This reveals a coin with two sides. On one side, nature can be defined as a neutral research object, with objective, clear, universal answers, which only need to be found and analysed. On the other side, nature can be described as life, independent from the human being. The human being shall not be involved in the research with his feelings and senses bounded to what is being observed. However, if researchers shall keep themselves “neutral” to the science and research, the human must be able to disconnect his ego, cultural background and set of values in his work. It can be questioned if this is possible. For research including for example complex issues such as human behaviour, ethical and normative issues, the researcher must be privileged with tools and a world perspective that includes the manifold of facets of the research questions. This might have to include tools, which challenge the personal experiences of the researcher and her ability to discover the importance of non-material phenomen in the field of research.

Politics

The politicians within a democratic nation are elected by the people to look after the interests of their society through legislation and resolutions. This requires from the politicians the ability to create organised systems based on common priorities and ethics, in balance with the economic prosperity within the society. The priorities in political solutions are also reflecting a political ideology, which is based on different worldviews, placing human in connection with nature, material, and non-material values. Referring to the ecocentric worldview, the "land ethics" lead to a political legislation, which aims to preserve the totality of biotopes. A parallel may be drawn to political protection of minority human cultures living close to nature. In an ecocentric worldview the protection will have to involve the local natural resources which is the basis of their culture and survival.

Society has evolved using monetary evaluation of physical products, non-material services, natural systems and life of different content. It happened for society and individuals to become able to compare different values and to prioritize the most productive or increasing value.The valuation is done from the perspective of the society, groups or individuals, who are evaluating the relative value of the “object of monetary valuation”. From an anthropocentric point of view, nature can be estimated after the single species’ or resources´ utilitarian value for human beings. From a biocentric or ecocentric world view it is hard to estimate the nature economically, since every single species and total ecological cycles have their inviolable intrinsic value. They can not automatically be replaced by another related species or another cyclic system. From this worldview a monetary evaluation seems contradictory.

The world has changed tremendously during the last two centuries. Ongoing from the development of the industrial revolution, we are now facing a so called globalisation. The power structure is changing. Global networks are built across the single nation’s authorities. Economic drivers can force single nations and societies to make decisions, which can be in discord with their own ethical points of view, but which have to be made in order to survive in the short time perspective. This can involve extraction of natural resources, importation of merchandise, building of infrastructure, choices of lifestyle and general organising of society.

The individual and society

The development of technology has given the aspects of ethics a new face. Hans Jonas talks about how the earlier human ethics would consider the personal meeting and agreement between people. Today, the ethics must involve the actions of a human being seen in the perspective of future generations and society as a whole. Actions among individuals will today in many cases become models or patterns for rest of society, and technological development will influence many nations. This gives an enormous responsibility to single persons, which is impossible to overview from the traditional point of ethics. Therefore Jonas refers to a more collective responsibility (macroethics).
He also points to the paradox of technology. Technology has been used to protect humans from nature. Since we are destroying nature at the present with help of technology, we are destroying ourselves, but we still believe that we will be able to use technology to change the direction, which led to the major challenges we see today.

The individual and the essence

The personal development via the creation of objects lies in the challenge to bring together the arts of mind, fine arts, craftsmanship and technology. Martin Heidegger´s philosophy thematises the essence (german: Wesen) of the technology, which can not be found in technology itself but in the human being and among the human beings. Heidegger points to the danger in believing that technology is predeterminated to develop in certain directions without the possibility for humans to make an influence of change (technology determinism). But to change and control technology one have to understand its essence, that means to reach an insight of the human being.

The individual and nature

Finding one as a human being, as a part of nature, given a certain role among other species, can change the human perspective on nature. From a new revised point of view, each species get intrinsic value in the ecosystem. The diversity and richness in nature will by itself be of unique value. Arne Naess introduced this close relationship between humans´ personal development and consciousness about nature as *deep ecology.* Based on the belief that human being as a part of nature has inherited the perception of holism in natural ecology, it is important to allow intuition become visible in decision making.

Ontology or ethics

Næss underlines in his work of deep ecology that it is not the question of ethics which is crucial, but the question of ontology. Ecosophical ontology means ideas, which can be grasped by others and exist collectively. It is a worldview and a perspective which focuse on the relationship between human being and nature, oneself and nature. Næss' ontological ethics say: If one really understands to be a part of nature, moral rules are redundant because the human will act instinctively right. Eco-philosophy is defined by Næss as the development and articulation of the basic, common intuitions of the absolute value of nature, which resonate with their own backgrounds and approaches, using philosophical methods.Ecosophy is, as an extension of eco-philosophy, a "path" for personal development that guides individuals to their private relationship of deep ecology.

Human experience, a source for reflection and insight

Identification with nature can be created through inspiration during one's own creation of objects and arts, living close to other living beings in nature, or experiencing relationship to other people. According to Heidegger, Næss and Jonas, these activities are revealing the crucial values for the human being and can lead to "moments of clear sight", e.g. the understanding of the connections between nature and human beings.

Products will not be able to fulfill non-material needs but they can possibly point to values and aspects of life, which draw the attention to spiritual needs, and promote activity, which consists of non-material or spiritual value.This is obvious in symbolic items and buildings, but can also be the case for other types of objects and systems.

Nature, fellow beings, social structures and material solutions are elements, which invite for interaction and represent objects for attention from the individual. The moment the individual gives her attention an experience is created. Sudden interruption can draw the attention involuntary from an individual, and will give unexpected experiences. An experience starts with an impulse or sensation reaching the body, the senses and the mind. The body is an enormous source for experiences through its natural rhythm, lifecycles, movement and change. The experiences can be consciously or unconsciously reflected upon, and lead to intellectual, spiritual and emotional insights.

"….the system begins with the immediate…the starting point of the system: spontaneous experience offers itself." Arne Naess 1989

Naess and Heidegger point to the moment of insight, or the turning, where an individual comes to a switching point, "moment of flash" through an experience, leading to the path of self-realisation.
The understanding or perhaps "moment of flash", can be mediated to others through e.g. literature, art, or design. Again the moment of communication to other people, may create new experiences for the recipient, and additional "moments of flash". A positive spiral has started and opens for the possibility of changing systems, solutions and ways of thinking.

Naess talks about the danger of becoming superficial in the ecological debate and in the search for solutions. "One should never limit the bounds of the problem just to make an easier solution acceptable." (Naess 1989)
To be able to study a complex problem it may be necessary to make some simplifications along the path, however, without loosing the sight of the landscape and its horizon. Art, culture as such and e.g industrial design are ways to communicate a holistic understanding of the human challenges.

Spiritual satisfaction can be connoted with a complete peacefulness, which is not achievable through single products. Nevertheless, experiences in relationships with material products starts in the process of creating them. Tools for production, however, are also products. This is just as important experiences as the experiences achieved in using the final products.

The individual and the common experience

The aim of designing product systems in harmony with nature and human, is not only based on the choices of materials and energy. To be able to change the systems in society, the system itself has to inspire the single individual to change the mindset to discover the connections between having a good life and living in balance with nature. Inspiration is among the spiritual fruits. If a product can inspire the user to bring an idea further, or create something new by himself, it might be possible to say it has an immanent spiritual value. Victor Papanek points also to the importance of the designer's and the producer's intention behind the product that is offered the customer. What message is the product a carrier of, and to whom?

"I firmly believe that it is the intent of the designer as well as the intended use of the designed object that can yield the spiritual value." Victor Papanek 1995.

Heidegger argues that to master the technology we have to understand it's essence.
To understand the essence of technology, what technology really consists of, we have to understand the essence of human. To understand the essence of human, another insight is required than the insight achieved through pure calculations. Fine arts and craftsmanship are approaching the holistic and primary desires of the human being, and can therefore provide a comprehensive reflection of the human being.

Naess points to the development of technology, how it has evolved without any control, without anyone accepting and planning the next phase. The serious part of the ecological challenges is the uncontrolled character they seem to have.

2.3.3 The paradox between mass production and human-ecological friendly solutions

Despite the search for completeness, mass production is an expression of a more collective development in society, where the single individual is degraded, concerning responsiblity and expected skills. The machines are now carrying on the the precision and knowledge required in many of the production processes. Regarding the dilemma of individual fulfilment and standardised fabrication, the question arises if it is possible to design products and productsystems of the type mass production, which can lead to experiences of the kind, that brings the individual closer to self-realisation. This should include the humans involved in all the processes through the total lifecycle of the product, and not only for the consumer in the end-userphase. The other phases interfere with working people and their daily tasks, but also people who are indirectly involved in the life of the product.

Mass production is dependant on the economic system, which is built to serve and maintain this activity. The legislation and resolutions made by the politicians are also supporting this type of production systems. The economic forces across the national boundaries are perhaps the most important influence on developing and increasing the global mass production. What is characterising mass production is the endeavour towards more efficient standardisation, specialisation and linear production lines. A postitive effect for many people is relief from hard physical work and lower price on commodities.

The science of ecology is characterised by complexity, diversity and symbiosis (Naess 1989)
From this perspective we can look at the mass production of products as we know it generally today, and discuss the system seen from the individual, the society and the ecological system point of view.

The individual and mass production

The individual has through history identified himself or herself with local traditions and nature. The cultural traditions are threatened by the standardisation, which as mentioned is characterising the mass production systems. Standarisations are meant to function independently of local conditions. The local traditions are often rooted in use of local materials and skills that are used and developed through generations. The Experience and knowledge concerning the total appearance of a product in a certain climate and conditions for use is colouring the traditional products.The manifold of cultures are in most cases based on the resources the local nature has to offer, to maintain life and support the society.

The mass production, on the contrary, offers often monotone work which gives the worker little responsibility or influence on the production and production processes. Products from mass production have to suit many people at a minimum, concerning function, aesthetics, price and so forth. Competing products often appear with similar expression, functions and use of materials. This decreases the manifold of products and distinctive products become rare. When a product is mass produced and sent all over the world, the distance between the producer and user of the product can be vast, and the product can be more unfamiliar to the buyer and therefore not cared so much for. The product become less suited for personal needs and may contain only a superficial message.

However, mass production gives the opportunity for more people to buy the goods needed. The economic system favours the mass products as cheaper than the one produced one off, or products including more handcraft and presented in a smaller scale. Higher living standard is also a consequence of the individuals having a secure, stabile job in the industry enabling people to buy more mass produced goods, promoted through commercials proclaiming a modern lifestyle.

The society and mass production

Local, smaller societies with few inhabitants are more vulnerable than central areas. Entire villages or towns become easily totally dependent on a single corporation because of it’s dominance as an economical resource. This can lead to political bounding where local traditions might not survive in the competition of labour and economic advantages.The diversity will therefore often decrease, and the specialisation can be a burden to the local environment, and the inhabitants.

Nevertheless, a stable industry will provide taxes to society and contribute to social development and privileges for the citizens. The secure occupation may lead to less people “falling out” of the system, which means again less expenses for the society. The industry is in different cultural aspects also an important economic support. The sponsor activity is seen by most business as a positive commercial promotion, and is vital for some cultural activities.

The environment and mass production

Producing in high volume at one location means there has to be transportation to the different markets and customers, often spread across different countries and even continents. The use of fossil fuel in transportation has well known impact on the environment, and should be avoided as far as possible. The concentrated pollution within smaller areas caused by the production processes is often a too heavy burden for the surrounding nature to absorb. This leads to a definitive or temporary destruction of natural resources or ecological life cycles. Local areas for recreation are often destroyed or occupied in favour of the industrial activity. The waste from mass production is often a dead end of the resources being extracted, and become the cause of many environmental problems experienced globally today. To follow own products and to close the material loops is hard when the entire world is your market. Although the production processes might be easier to control and are made cleaner for large mass-product volumes, the remaining product lifecycle might be harder to control, and the contact with the end consumer might be impossible establish.
The developing countries are affected with the same problems, which comes with the industry with low focus on local conditions and ecological vulnerability. Many countries have in addition other basic problems to solve concerning essential needs of the population, e.g. access to acceptable clean water.

Industrial designers as change catalysts

In the global trade today there are strong drivers pushing every system to continuously increased speed and economic efficiency. The ends are less important than the means to most of the companies. It may seem that the designer is standing in an impossible position, where the only realistic move is to follow unconsciously the current economic drivers.

Hans Jonas concludes there is no possibility to turn back the development of technology, but is it possible to use and develop the technology to change the system of mass production?
Martin Heidegger, might have said, it depends on the human and how we understand the human nature. Arne Naess may point to the path of self-realisation, where we experience the connection between other living beings and our own existence. The need of change in consciousness is seldom

mentioned ecological debate, but now more individuals are bringing this up and working for a change of the systems. Naess is referring to Erik Dammann (the founder of the Norwegian NGOs “The future in our hands” and “Forum for new system debate”) maintaining that “only blaming the system is pacifying”. He believes that the majority of people have a choice about the preservation of non-functioning systems in many ways. Blaming the system is destroying the possibility of changing it (Arne Næss 1989).The history of industrial development and evolvement, show many shifts and changes in ways of creating businesses and products. The worldview has changed and is still in alteration.

2.4 Design framework for sustainable development

As mentioned, there are different directions in research and development for sustainable product and system development. The most dominating is representing a technological optimistic perspective (STD, Netherlands 1997) combined with a claim for economic and political change of valuation. Taxation of environmental impact from production, transportation and waste treatment, and a change of focus from material product to service economy, are major shifts expected in the future scenarios (STD, Netherlands 1997). From perspectives in product design, it is also seen that the product strategies of a corporation is becoming more closely connected to the corporate strategy. Through *strategic innovation* new products and services are developed targeting gaps in the market, where customers are in lack of a good product solution (Markides, 1997). This is also discussed in connection with eco-innovation, but more in the focus of product technology (STD, Netherlands 1997) (Fussler and James 1996) than within the perspective of *uncovered user needs.*

The questions of value priority and focus in the design process usually have a strong effect on the appearance of the final solution; like a child being occupied with the details of a person’s hand in a drawing tends to give oversized dimensions to these details compared to the rest of the person’s body. To balance the values seems important in the design methodology for holistic solutions. This section will present some rather humanistic and qualitatively focused perspectives and frameworks for design and development.

2.4.1 Designing on basis of acknowledged insight; Eco-design built on eco-philosophy

New insight can always be reached. This can be implemented in new product concepts, which create room for new experiences, both producers of the total concepts and the end users. The consequences of theses experiences will reveal the fruits of the main idea or intention behind the product. Life quality in a sustainable society can never be a final goal but qualities, which are always challenging to work for. These qualities may influence and change the desires and needs in the market. The development towards a sustainable society may demand the processes and priorities to become more consciously accomplished.

There are different directions of eco-design being practised today. The worldview of the practitioners differ and so do the methods. Some practitioners believe in technological solutions, and that the right choices of energy and production processes will solve the environmental problems. Other practitioners want to balance the human created systems with the natural systems and focus on the human life quality in the perspective of intrinsic value of nature.

To summarize the argumentation in the philosophical discussion (chapter 2.3) we might be able to draw at least three principles to promote sustaunability through design works:

A. The conscious choice of a worldview is important to understand the reason for own decisions, to know what ethics they are based upon and to be able to see the consequences the choices might bring. As an eco- designer there is a need for a conscious knowledge of the connection between human life and nature. This should lead to inspiring guidelines solving both human and ecological problems.

B. Products and systems can neither fulfil the spiritual needs of human being nor make the life of a person complete concerning life quality. However, products might draw the attention of an individual, invite to experiments and give experiences, which can inspire to further activity, contributing to an understanding or “moments of flash”. These moments lead the individual on the way to self-realisation, which does not mean self-isolation, but in contradiction, means to see that one is actually part of a totality including nature and other human beings. (Naess 1989, Heidegger 1969, Jonas 1994). In this sense the product is an important catalyst; means to achieve other goals. Next to solving a concrete need, the activities made by the user can be the main purpose of the product concept.

C. To create is part of the human nature, and through creative processes, fine arts and handcraft, the individual will reach an insight in the self and in the essence of being human (Heidegger).
This speaks against the mass production as it is generally known today, both concerning the need for individuals to understand how to start changing the system, and concerning the ecological impact it is the cause of. To create and understand the processes opens for the opportunity to influence and change the system. There is then the challenge to the eco-designer in co-operation with transdisciplinary project groups, to design solutions which make this possible through out the lifecycle of the products.

Three examples from industrial design activities

A. The worldview represented in the choice of material flow:
Business Company Kafus works with the development of renewable and biodegradable materials. The materials go in closed lifecycles from biosphere to technosphere, returning to biosphere. The man behind Kafus, Kenneth F. Swaisland, formulated the mission: "To become a global, low cost producer of commodity materials made from sustainable alternative resources."
In concern of the environmental problems, Swaisland wanted to develop technologies which could change the way commodities generally are produced. Kafus is financed on special agreements for long term raw-material supply, long term purchase and is supported by finance, which is not obliged to the stock market. This enables Kafus to concentrate on improving their products in both long and short term.

Some of Kafus' products on the market are: medium density fiberboards from the use of 100% recovered urban wood waste, natural fiber composites to replace fiberglass and other non-recyclable materials, tree-free newsprint, fiber cement, and organic fertilizer. Kafus is manufacturing from sustainable agricultural and recycled materials. All through the product lifecycle, the connections to nature and humans are effecting and giving the idea to the total business concept. The solutions found are built on a worldview including conservation of non-renewable resources and awareness of the ecological cycles.

B. Modern technology as catalyst for inspiration and common experiences:
"Virtual source of knowledge of food" was a grauate thesis project in industrial design (Wigum 1996), carried out at the School of Architecture, Oslo, Norway. The goal was to design a product concept bringing together the spiritual, natural and humanistic life cycles. Through the use of electronic/digital solutions the project was also partly an example of the use of immaterial design in human and ecological aspects. Briefly explained, in this project the product concept (which still has not been created in real life) is placed in a more total situation, "the connection point", a local centre, where all generations, old and young, are offered different facilities for their daily duties (*Illustration 2*).The meeting point in daily life, is the kitchen and the dining room.

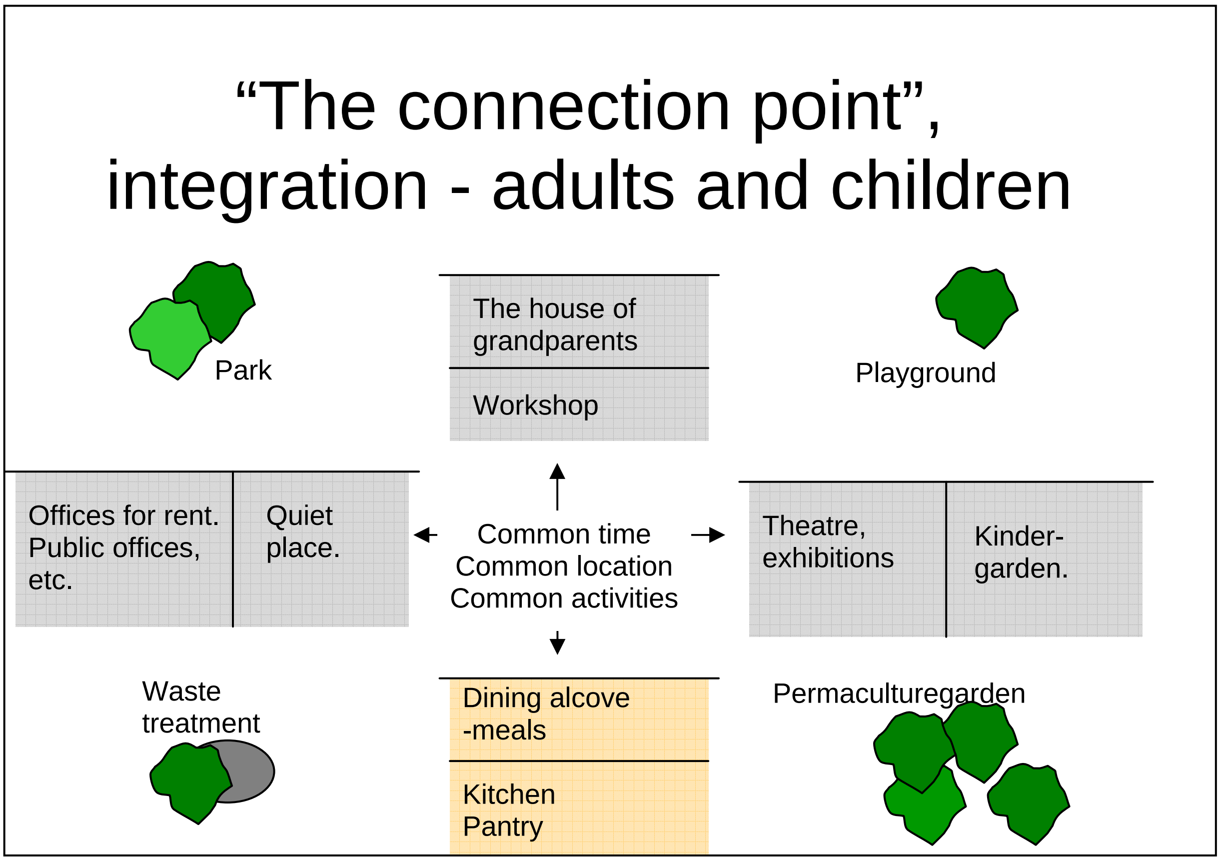


Illustration 2 "The conncetion point", conceptual sketch of the area with daily activities for adults and children (Graduate thesis, K. S Wigum 1996. Supervisors: N.P. Flint, M. Krafft and M. Hansen).

Here they will find the "virtual source of knowledge of food" (*Illustration 3*). This product concept is a computer book, guiding both adults and children into the world of food of all kinds; traditions, religious feasts and daily nutrition. How to preserve, treat the ingredients and find the fruit and vegetables of the season is also shown through smaller video shots, pictures and story telling. The information and communication is reached through a software program made for this cordless computer-book linked to the internet.The purpose of this product is to re-educate adults and children in food culture of all kinds and inspire to activities in the kitchen. To inform about the lifecycles of different ingredients might give a new understanding of the ecological and human created cycles. The product itself is not essential but rather the consequences of the usage.

Illustration 3 The introduction web page of the electronic cook book (Wigum 1996). Translation of the main menu: Meal, Recipes, Drinks, Ingredients, Purchase of groceries, Preparing/Cooking, Nutrition, Waste treatment, Seasons, Spirituality, Production and Life cycles of food, Culture.

C. Locally based production
The utilitarian and intrinsic value can also be discussed concerning material products (Walker 2000). Having an utilitarian view on products can lead to higher consumption and rapid exchange of the products, on the other hand the need to collect items will be less, and the building of own identity through products will be less interesting. Giving products an intrinsic value might bring people to the action of repairing and taking care of their property. This might decrease the exchange of products, but again a person's identity might be more bounded to what he or she owns. Stuart Walker at the University of Calgary, Canada, has made a research project about the production of products based on partly mass produced elements and partly onlocal based handcrafted or disposed/recycled elements. The general issues of the project were to create a combination of utilitarian and intrinsic values in the products, and respond to environmental, economic and socio-cultural concerns in a balanced way.

The artifacts as results from the project was various furniture, lighting and electronic products (Illustration 4 a and b). The intention behind the results together with an understanding of the ground ideas was to provide opportunities for discussion, reaction, reflection and response.

Illustration 4 a and b Stuart Walker, a. the arc lamp, b. the tin radio (1999).

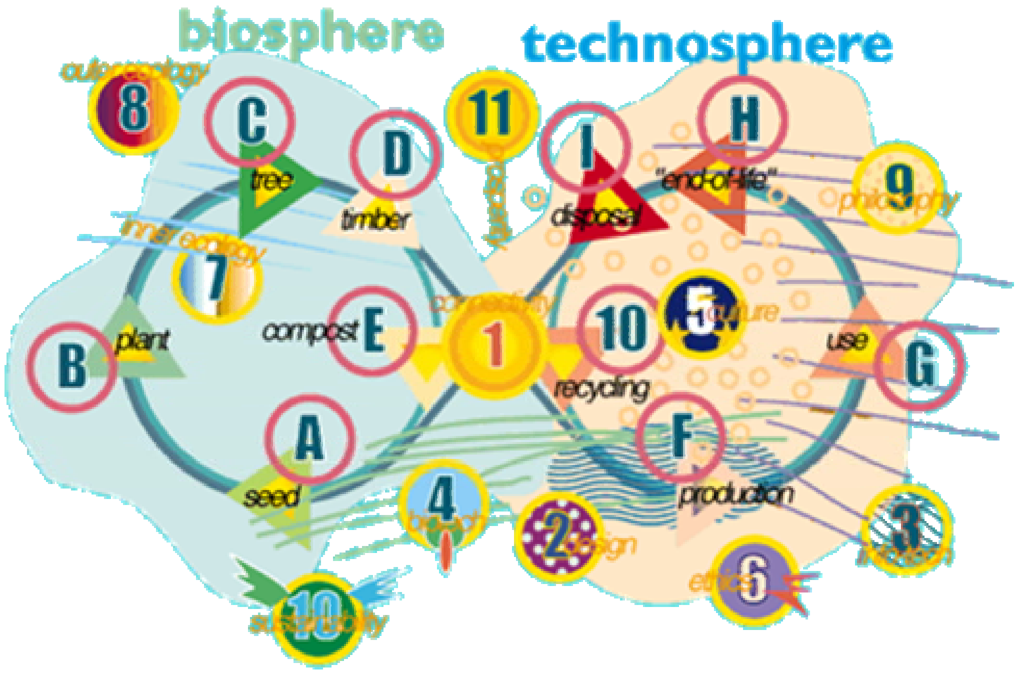
It is difficult to walk across towards other disciplines to find a broader perspective for ones own professional solutions. The differences among the professions in terminology and scientific traditions may build barriers, but going into essential questions, these differences can make the discussion richer. The complexity in implementing new insights from other disciplines into ones own profession is creating a challenge but also a vital field of research.
This written section is an experiment, trying to implement eco-philosophy into the thought and practice of eco-design, without compromises. The result may at this stage appear as a sketch of design for sustainability. Perhaps the thoughts of tomorrow must appear as aliens today, to present new possibilities that can change the systems into sustainable directions for the future.

2.4.2 “Design for the real world”, Papanek

The literature in eco-design is proliferating along with a continuously growing interest in different fields of both practice and research. Victor Papanek was one of the first industrial designers, who brought the ethical and social responsibility to the market among designers and companies. He wrote his book “Design for the real world” in 1968, which made him very unpopular within his own field in the USA. Papanek represented the humanistic direction within design. Papanek discussed the role of designers and the importance of their awareness in the design process of the product consequences. He also discussed the social welfare and how design could involve and empower people in daily life as member of a society. Papanek published “recipes” for furniture design in newspaper and magazines and “how to make your own furniture” using the materials, which were locally available. He was also engaged in the developing countries and how designer could do projects on the premises of local culture and real needs. Regarding Papanek it is still important today to create a balance between the technological and humanistic approach within the complex questions concerning sustainable development.

2.4.3 Cradle to Cradle and Ecological sensitive design, Mc Donough/Braungart, Wann, Flint

The understanding of lifecycles in nature itself and how human activities are influencing those, is of main importance to find healing solutions to the ecological problems. Nature itself can be used as inspiration to find basic solutions in how to treat materials, and how to understand the possibility of transformation which we can be seen for organic materials. Nature has sophisticated design solutions on single elements and detailing but also concerning logistics and complex systems (Benyus 1997). Mc Donogh and Braungart are suggesting a methodology, which divides the technological food (materials) and the biological food (materials). Waste from these different types of material processes should return to its own source and become food in a new product life cycle. The products must be composed by a consequent use of either the technological or the biological materials. If a combination is preferable, disassembly must be easily performed in order to complete recycling in separate loops. However, as illustrated by Niels Peter Flint (Model 1), the technospere will always interact with the biosphere in some points. This is where the human made systems must be more sensitive to the processes that are continuously preceding in the natural eco-systems namely the biosphere.



Model 1 The Flint model, illustration of a whished material cycles between the human made technosphere and the biosphere of nature, creating the framework of human experience. (Niels Peter Flint 1996).

By establishing connections between companies and their different types of customers through the total product's lifecycle; the flow of materials and energy might be controlled and used optimally.These connections can be made through service support systems. *Industrial ecology* is the creation of flows between the biosphere and technosphere, involving the materials and energy into as many controlled and closed cycles as possible (Wann 1996).The product Biogran (Illustration 5 a) is an example of a product where biological material (human waste) is transformed to a new state, which introduces functions that lead the product back to the biological cycles as organic fertilizer.

In a long term perspective the use of some materials should decrease and others should replace them. The use of materials, which are already in circulation must also be considered as a future resource through reuse, recycling and energy extraction. Renewable energy and materials should replace the virgin non-renewable materials. The product Tsola (Illustration 5 b) is an example of street lamps based on renewable energy through solar cells**.**


Illustration 5 a and b Biogran (2 a), is produced from human sewage sludge transformed to a mineral-rich and slow-release organic fertiliser and soil conditioner (Wessex Water, UK). Illustration 2 b is Tsola light, which has internal solar cells transforming energy to electricity and light that switches of at dusk and off at dawn. No wires are necessary(Redesign, Sustainability in new British Design, 2001).

2.4.4 "Deep design", Wann

David Wann is in his book, *Deep Design* (1996) describing how design can be based on a philosophy from the Eastern material art discipline; Aikido. Aikido is not forcing processes more than necessary and is striving towards resolution rather than conquest. Wann is discussing how this approach can be used to find solutions and solving both environmental and social problems. The idea includes looking upstream and discovering the reasons for problems rather than focusing down streams on the symptoms, and making connection between what goes out and what goes in (Figure 14).

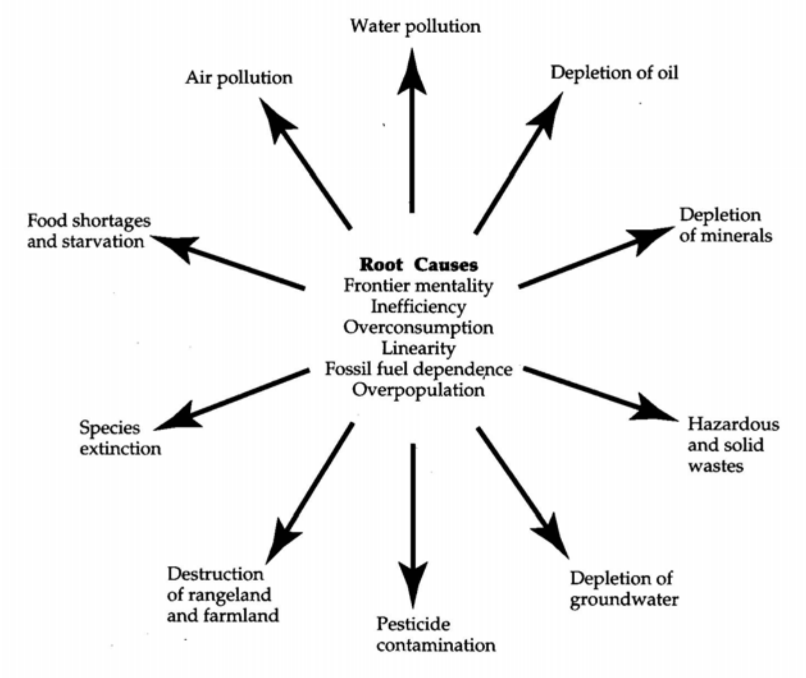


Figure 14 The symptoms of unbalance are followed upstream to the root causes in order to find sustainable solutions (Wann 1996).

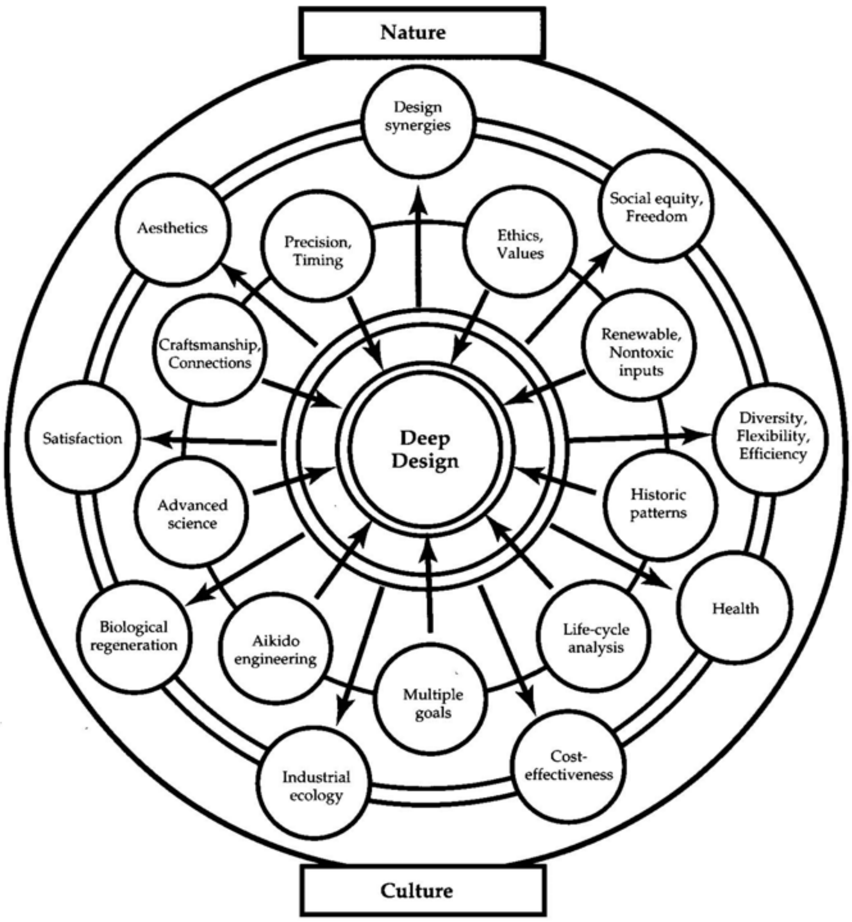


Figure 15 Deep Design is in dynamic relationship between nature and culture (Wann 1996).

Deep design is foucusing on “how to think it”, “ more than “how to do it”, and Wann has a wide definition and implication of the word design. He points to the challenge of integrating the diverse designs into one grand design or *sustainable culture*, as Wann describes it (Figure 15).

2.4.5 Slow design, Fuad-Luke

Citta slow was a concept introduced in the mid 90’s and has inspired other concepts, such as slow food and slow design. The basic idea is based on preserving values which are connected to slow speed activities. Ezio Manzini (2002) is discussing the lack and loss of contemplative time, time for doing nothing, which used to be seen as a privilege owned by the prosperous part of the population. Today, it is seen as a declining phenomenon, which some people want to take back. Citta slow is a concept introduced in smaller cities and villages, which include in their profile of the good life, through authentic experiences and absent of stress. *Slow design* (Fuad-Luke 2002) is presenting a direction within design which is also based on the key word *balance* by which the “slow” philosophy can be described. Energy and efficiency is created and growing in the process of slowing down (Honore). Slow design is a new concept within the slowness movement. Alastair Fuad-Luke (2002) is discussing a new paradigm within design which is based on a new framework that can be seen as a summary of the human sustainability principles (Table 7).

‘slow design’:

?? balances the well-being of individuals, societies, cultures and the environment
?? focuses on creating a sustainable today and tomorrow
?? considers physical, emotional, mental and spiritual durability important
?? celebrates diversity, is pluralistic
?? balances the benefits of localisation with those of globalisation
?? requires equity between humankind
?? celebrates a culture of largo
?? creates a new, strange beauty which responds to all human senses and values

Table 7 The framework of Slow design suggested by Alastair Fuad-Luke (2002).

The Natural Step
The natural step is a Swedish initiative that has become an international commercial network for consultancy concerning sustainability issues in industry. They focus on a synergy between science and practice and have introduced an eco-compass with four major principles defining a sustainable society.

The natural step is approaching the sustainability issue from a slightly “untraditional” side and is defining what a sustainable society is *not performing* (Table 8).

In the sustainable society, nature is not subject to systematically increasing ....
1)... concentrations of substances extracted from the earth's crust.
2)... concentrations of substances produced by society.
3)... degradation by physical means.

and, in that society ...
4)... human needs are met worldwide.

Table 8 The four principles in the framework of the natural step (source: http://www.detnaturligasteget.se/DnsSwe/Start/)

The four system criteria in The Natural Step (Table 8) is following the premises for a “strong” sustainability described in chapter 1.1 and 2.2.

2.5 Design products as value carrier and problem solver

2.5.1 Scandinavian design

In the period between 1950 and 1970, the term Scandinavian design was used on a series of products and interior design designed in Finland, Denmark, Sweden and Norway. The term was initially used in the USA, and served as a description of the products designed in the Nordic countries based on social values and “honest” expression. The products where meant for people in general and not specific strong economic segments in the market. Typical for this design was the use of natural materials, visible constructions, simple production processes and thoroughly treatment of the shape in connection to use and function. The social perspectives were reflected in the cultural focus of bringing beautiful objects to the pubic with low cost. The Nordic modernism was emerging through the aesthetic expression signalizing the welfare based on equity, security, harmony and balance. The products from this period are, however, diverse, and some designers started to experiment also with synthetic materials, such as plastics and production technology. The combination of mass production and craft was introduced (Wildhagen 1988). This design ideology was recognized later as a rather naïve movement, designing products without provoking or actually solving real problems. Fredrik Wildhagen (1988) mentions the last international design award given to a Nordic cooperation of design as a paradox since it was a project concerning public environment. This was not a theme of high acceptance among the somewhat craft oriented Nordic designers. The critics of the Scandinavian design called for a stronger social engagement in design also for the developing countries (Wildhagen 1988).

2.5.2 Social conscious design/Corporate societal responsibility

Max Havelaar is a fair trade label (*Illustration 6* a and b)originally initiated in the Netherlands in 1988. Today 17 international countries are involved and in 1997 a numerous of Norwegian organizations cooperated in constituting a Norwegian Max Havelaar Fair Trade label system. The label is based on criteria concerning social, economic and democratic development. The ethical perspectives and guidelines ensure the producers a fair price for their work, and the label is a signal to the consumers that the products have been purchased through fair trade conditions (source: www. maxhavelaar.no). Some of these labeled products of food are also based on organic farming.

Illustration 6 a and b The new international label of Max Havelaar and various sorts of food stuff products (www.maxhavelaar.no).

There are several labels for environmental product criteria and organic farming approvals etc. The design of new products is affected by these criteria, if the business and marketing strategy is including the goals of label approval. These labels are not steered by governmental demands but founded on consciously chosen priorities based on different sets of values.

Corporate societal responsibility has become a concept which is operationalising the social initiatives performed by industry. A number of agreements and ethical guidelines are developed and can be agreed upon, such as UN Global Compact and the Universal Declaration of Human Rights, ILO-conventions and the OECD Guidelines for Multinational Enterprises (source: www.Nordea.com).

Design with no borders is an initiative by Norsk Form (Norwegian Center for Design, Architecture and Urban Building Environment). Design projects are executed in for example Guatemala, Brazil and Mozambique. The design projects are placed within two strategies:

- Makeshift, natural catastrophes and crises
- Long term development for life improvement

The projects are contributing to areas where economic drivers and a developed infrastructure is rather absent. *Design with no borders* is supported by unlike NGOs.

2.5.3 Inclusive design

Universal design is a relatively new expression in the industrial design terminology, which is based on the philosophy that designed products and systems should inhabit a flexibility that enables all type of users to utilise the posed functions. This is especially welcomed in the public picture. The terminology has in the last years been transformed to “inclusive design”. Universal or inclusive design is based on 7 “universal design principles” (Bendixen 2002):

1. Equitable use
2. Flexibility in use
3. Simple and intuitive
4. Perceptible information
5. Tolerance for error
6. Low physical effort
7. Size and space for approach and use

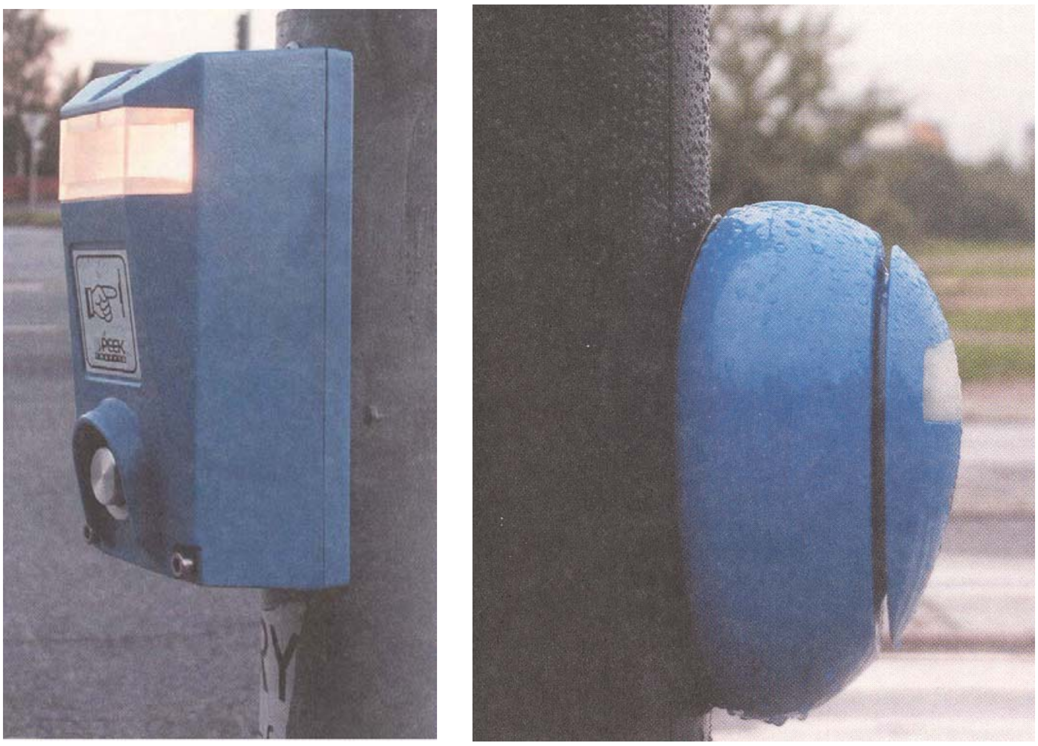


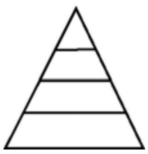
Illustration 7 a and b Peek traffic has two versions of the same product.The left product must be operated with one finger, the right product designed with "universal design principles" offers many optional possibilities; the arm, the elbow etc. (Bendixen 2002 ,Foto:Cristensen, Form & Function no 1vol 1, 2002).

The inclusive design principles have most often a direct consequence to the balance between the function and shape of a product. However, the products must also be seen in close connection to the user activity and the surrounding system in order to result in a completed inclusive solution. As an example the product from Peek Traffic (Illustration 7 a and b) which is assisting the pedestrians crossing a road on “green man”, must be placed in a suitable height, which means not to high in order to be used by children and persons in wheelchair.

2.5.4 Empathic design

The need for more appropriate solutions in society, has lead to the relatively new concept *empathic design*. This concept explicetly calls for the designer and company to get directly involved with the customers or users of their final products. This is done through several methods whereas one of them is observation of the user while interacting with the actual product solution. The main goal is to reveal some of the unspoken needs and more or less unconscious patterns of behaviour (Burns 2003).

Designing based on the image of experiences
Erik Lerdahl (2001) is introducing in his thesis a conceptual model (Model 2), which is connecting the discussions of non-material values, spiritual aspects, myths and personal experiences within the development of new product concepts. Lerdahl is focusing on the use of specially developed and existing creativity techniques to promote these aspects and inspire the development team to think differently in the initial phases of the design process. This type of approach is also of clear importance in development of new concepts considering both human and ecological sustainability.



Abstract	**Spiritual** *Intention*	Philosophy, values, intention, myth, identity	Value carrier
	Contextual *Expression*	History, staging, interaction, sequences, style	Social actor
	In principle *Concept*	Product structures, Principle form & function	Product idea
concrete	**Material** *Product*	Product details, materials, finish, production processes	Production processes

Model 2 Vision based model, describing four levels of abstraction for products (Lerdahl 2001).

2.5.5 The Shakers’ design for divine judgment

Design may also express specific religious worldviews in the performance of production and aesthetics. The Shakers is a group of Christian believers, who broke out of from the English Quaker society and moved to USA in 1774, where they created their own society led by Ann Lee.
They were forbidden to draw or copy nature in any form and thus developed non-figurative patterns and a minimalist design of every day products and housing interior. To the Shakers God was ubiquitous and watched all work and activities which was always done to His honor. All furniture would therefore be of the same high detailing and quality on the backside, facing the wall, as in the front. Simplicity, integration of functions and homogeneity in material use were their distinguishing characteristics in their time.
“As they sought to create their vision of “heaven on earth,” they applied the virtues of simplicity, purity and perfection to their work and to themselves.”
(source: www.hancockshakervillage.org/old/shakers.html)

2.6 The ideas of non-materialisation and dematerialisation

In many engineering and economic perspectives “dematerialization” is a term, expressing how the economic value is increasing compared to the units of material end energy resource use. This is a measurable definition; however, it is not including directly the environmental benefits. It is a strategy within eco-efficiency, but is also a natural approach in traditional and good design practice aiming at reducing weight and material consumption, which usually includes good economy. Integration of functions, technological evolution and change in material and production processes are typical contributors to this strategy.

Non-materialisation would rather introduce human assisted activities, or reduction of concrete products that are replaced by total new solutions. This first concept, introducing human power and service, is against the Western trends where human employment is expensive compared to product solutions. The latter product focus is typical for high tech development but not necessarily an environmental benefit in a system perspective.

2.6.1 Product Service systems as non-materialisation

The new trend within eco-design is to involve the thinking of services as well as products. There are several approaches reaching from adding a service to an existing material product, towards excluding the material product and create a *non-material solutions*. A non-material solution is in this context defined as a service or a system, which is operated by and through people instead of functions in a material product. *As a product extension*, digital technology can support the service functions related to the product. The company behind this type of solutions may increase their business activity, producing services based on human capacity and/or digital support systems, instead of increasing their production and development in quantitative material units (Pine & Gilmore 1999) (Figure 16, Wigum 2000). The design concept consists of an interaction of services, non-material systems and material products (Figure 16). As a part of the concept the customer can be served in understanding the product, being able to use the functions in a more optimal way for his or her own special needs. This can provide the customer with an insight into the origin of the product and the company(ies) behind it, by telling the story of the total product. Further, this may contribute to the user loyalty through closer bondage to the product, higher satisfaction and thus lower frequency in exchange of products and perhaps less consumption.

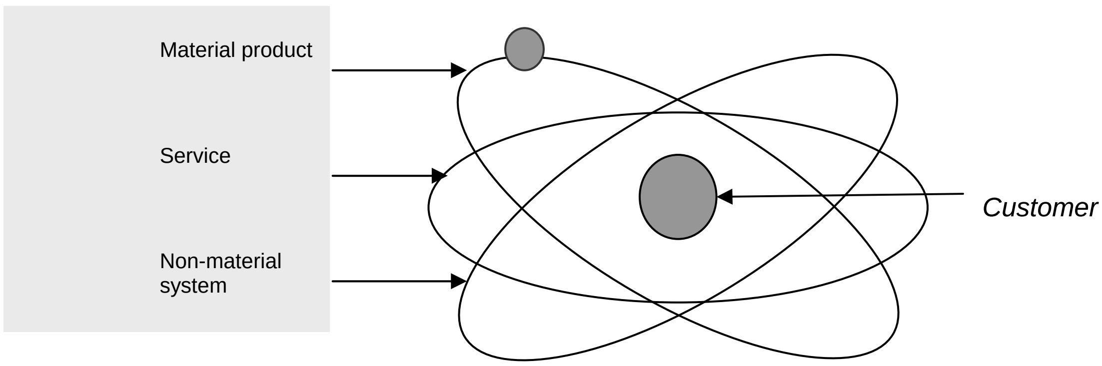


Figure 16 The company increases their activity in non-material systems and services, and in quality of material product, instead of increasing quantity of material production units (Wigum 2000).

The purchase of a product can also be conducted by service systems, which assist the customer and *the recycling firms* to co-operate in the product's end of life. This way the product can to a higher degree be secured an intended route based on ecological principles.

System design with user- involvement, starting with the preparation of raw materials

"The green furniture" is one of the concept pilot-studies, which shows that the sustainable principles may be used in development of high quality products. This project is also an example of how traditional products produced in a new way by old traditional materials and production processes may promote radical changes in a modern society.The project is described by Kaare Eriksen in *–a domino project, The green furniture* (1999). A concept, where furniture is produced based on local raw materials, local producers and craftsmen. The design of the furniture is delivered by a "designer pool" who has presented a numerous of available solutions. Eriksen is specifically describing a project in

Aarhus, Denmark, where a large amount of elm trees were diseased and had to be cut down. The cutting of the trees was made into a public event, where all the dwellers in the area of the trees attended. The trees were marked with numbers according to their original place of growing (Illustration 8) and the people, who had lived closely by the individual tree could order a piece of furniture from that elm. The furniture were produced by local businesses, treated with natural furnish and the fillings were of biomaterial from the area. Old knowledge had to be rediscovered in order to complete the furniture totally by following the sustainable principles of using only renewable materials.

Illustration 8 The Green Furniture, happening in Aarhus. A tree is marked before it is felled and used in design of furniture (Eriksen 1996).

2.7 The challenges in design on system level

The design knowledge must enter the top management level in order to become strategically applied. System design and co-operatin between actors in networks is a business strategic concern. Integrated product design is a necessary condition for long term thinking in design, including design for sustainability. The values chosen for a design solution should be a reflection of the company values in order to support a clear communication the customers.

2.7.1 Eco-Innovation or innovating the eco

In his dissertation (2001) Chris Sherwin is discussing the eco-innovation approach and how design is addressed in a company in connection with ecological issues and innovation. He is studying the issues in terms of electronic products for kitchen activities designed in a pilot-study in co-operation with Electrolux. However, part of the conclusions in Sherwin's work is that innovation is demanding the eco-design task evaluated in a system perspective and not only as a single product (Figure 17). Increasing the system boundaries means to introduce new perspectives to designers and developers.

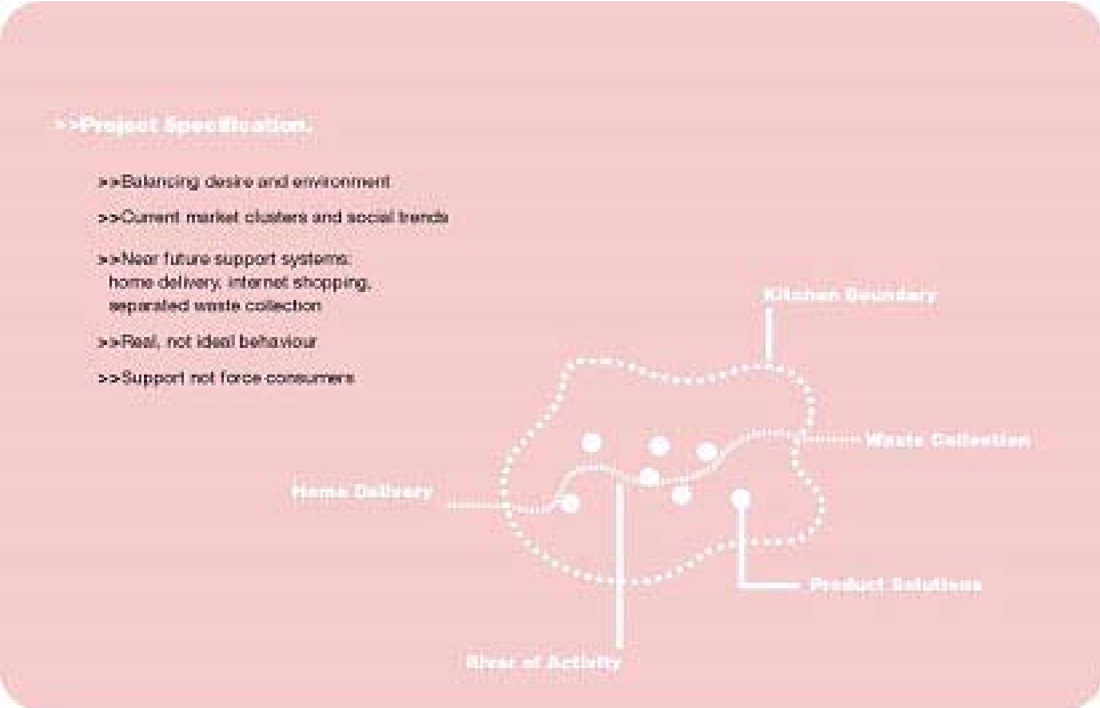
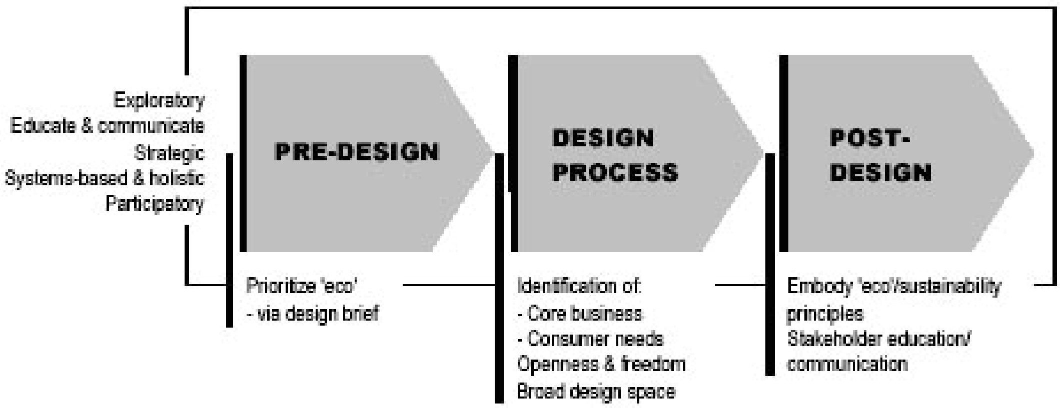


Figure 17 Products need to be evaluated within a system in order to achieve eco-innovation (Thompson and Sherwin 2001).

The eco-design activity is also depending on the surrounding support and business organisation. Sherwin is therefore introducing a pre-design and post design stage, embracing the eco-innovative activity in the company. Sherwin is also mentioning the importance of co-operation and openness, in order to perceive new possibilities and take action according to them. Different from the other eco-design methodologies, Sherwin is including important aspects of the human processes within eco-innovative design projects, such as education and communication (Model 3).



Model 3 Conceptual and descriptive model of innovative ecodesign.The model of Sherwin (2001) is including perspectives that pinpoint the human processes necessary in innovative projects, such as communication, education of involved parties, and participatory approaches.

Eco-innovation and sustainable business concepts

Sustainable business development is according to Claude Fussler, driven by a strong vision. This is built up through real needs in the market, balanced with the customer's affordability of the products and services, and cost of the production and realisation of the total product.

Other important factors are

- A management, which is able to set result oriented and ambitious goals.
- A management, which empowers the employees through a built strategy, and drives a process of continuous improvement.
- Economic steering and close contact with suppliers.
- Passion throughout the company, believing in their own concept.
- Working in dialog with actors in society (NGO's and politicians), extending the horizons.
- Building an own long term vision of sustainable future and the role of own business.

Keeping the direction towards sustainable solutions Fussler promotes
six rules whose one word summarizes form the mnemonic ECO/ECO:

Eco-efficiency (you must achieve more from less).
Customers (Consider your customers' long term needs even before they do).
Objectives (Set ambitious objectives and targets for sustainability).

Empowerment (Sustainability means empowered employees, citizens and communities).
Care (Sustainability is about ethics and socio-economic security as well as environment).
Out-of-the-box (Sustainable development is imperative possible and value creating. Someone will make it happen. The choice is yours.).

The development of new technology and products

Fussler and James (1996) mentions the three major drivers for eco-innovation:

- Demographics
- Environmental stress
- Changing mode of value creation

Fussler and James predict here will be growth, but of a different kind; customers, but with different values; profits, but based more on service and intelligence than moving mass.
This may demand an alteration for many businesses both in terms of the organization chart and the the organization culture (Appendix III, and IV).

2.7.2 Design management for value integration in system and product designing

Long term vs. short term

Building sustainable frameworks (e.g. politics), systems (infrastructures etc) and activities as such in society is a long term issue. The terminology "sustainability" inhabits in itself a long time perspective, actually infinity. To follow the consequences of today's systems, life styles and products is therefore a matter of curtain in the design for sustainability, on the other hand, the ability of visualising something *new and different* is maybe even more important (Dewberry and Sherwin 2002).
However, short term steps must also be taken for the long term development. Organization development (and change) is an independent field of research (Cummings, Worley 1997). The subject is however of crucial importance when the design task requires a change in values and culture. This is an enormous challenge even in smaller companies, if not impossible, and it can therefore be questioned if new business concepts based on sustainable values in a long term perspective must be developed from scratch. However, there are businesses which have introduced the long term scenario building parallel to short term activity. The petroleum companies like BP and Shell are focusing on their future energy concepts based on renewable energy sources, and are defining themselves as energy deliverers rather then fossil fuel extractors. However, the long term perspectives must be accompanied by strategies affecting the short term steps in order to have an influence on the actual company activity.

Scenario building for the possible and wished future

During the last centuries the paradigm provoked the technology to address the guidelines for how a society should change. Tad Mann, an architect from Cornell University asked the question, how technological development can be driven by needs formulated in the society. By organising a workshop where the participants had to think 55 years ahead, the technology came out of focus, nobody could predict its evolution or revolution that far in the future. The discussion circled around the values and structure of needs and the way material things are created in the society. After brainstorming the theme “fundamental needs” and “wishes for the future”, three keywords finally made the consensus: love, wisdom and beauty (Ted Mann 1995).
Scenarios are supposed to be stories telling us how it can be or how we want it to be tomorrow. The word scenario comes from the theatre, and means the setting of the script or play. (Fussler and James 1996)

Using scenario techniques to build business strategies for eco-design is a method to visualise the possibilities and consequences of different priorities. Robust scenario building on basic human needs, is the source of more innovating business concepts, which have the essence to survive the uncertainties in introducing new concepts for a future market (Fussler and James 1996).
From this point of view, the scenario building can describe a possible context for a future activity or be a scene for long term goals through visualisation or description of important values that are highly evaluated and should be preserved for both the short term and future solutions.

2.7.3 Organisation development and change

The model of Cummings and Worley (1997) (*Figure 18*) shows that asking the questions of what to produce, which values should be created and how to relate to the environment; are clear strategic issues. In order to change or improve these issues and activities, strategic interventions need to be developed and implemented.

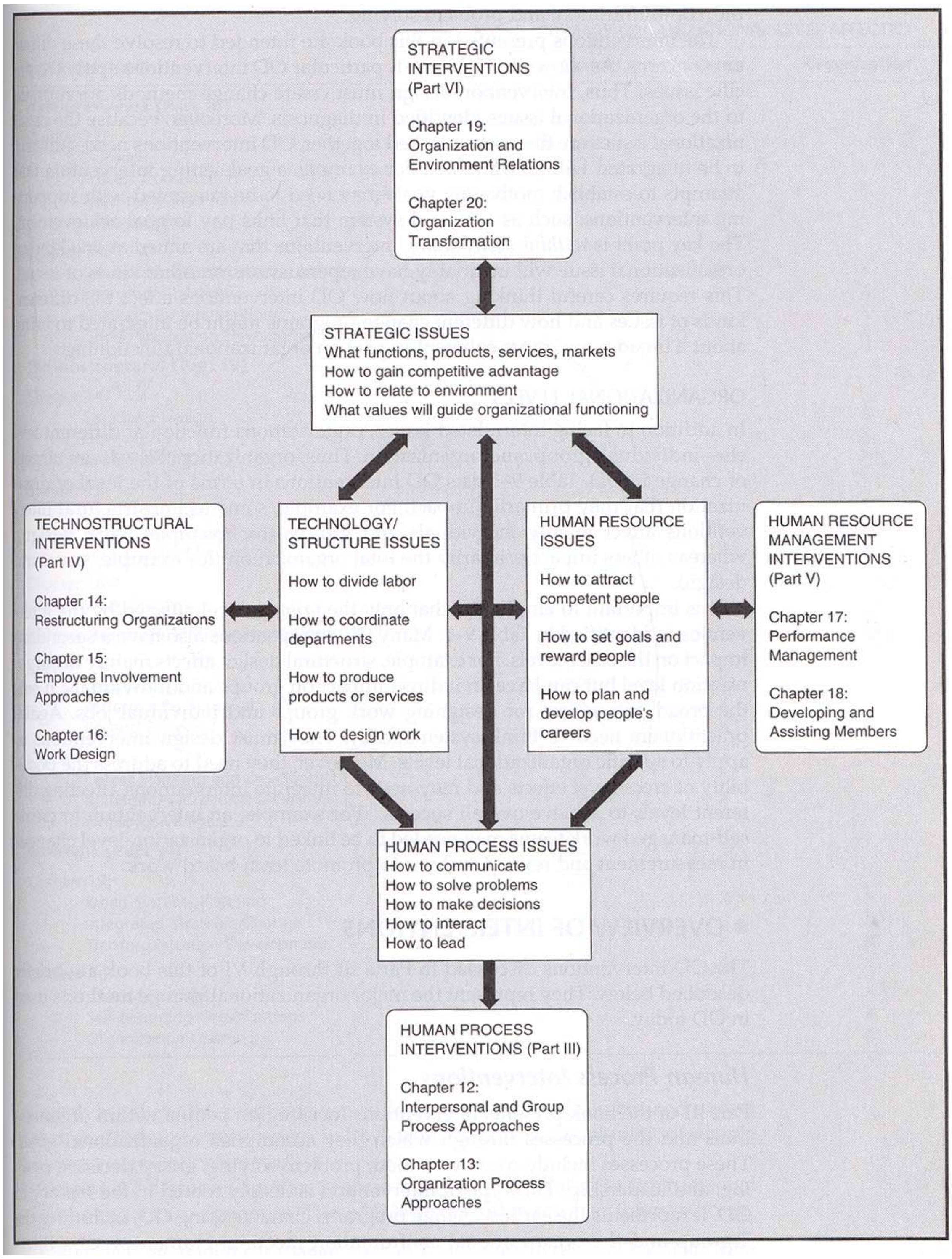


Figure 18 Organisation structure (Cummings and Worley 1997) Which functions, products, services and markets to focus on is a strategic issue, so is the environmental questions.

Incremental improvements rather than fundamentally new product development is the case for many companies. Business strategist Gary Hamel speaks of “corporate anorexia”. He sees that years of cost cutting and reengineering undermine the vision and the will to develop new products and build new markets. There may be many reasons;

- risk aversion caused by regulation and strict liability regimes
- growing development costs can be afforded by only a few players
- ageing workforces and job insecurity erode creativity
- low investment in fundamental research and development

2.7.4 Industrial ecology a concept based on material and energy networking

Industrial ecology is a concept inviting companies to cooperate between and across the flows of energy and materials. The production of products and services is involving numerous stakeholders, which have to cooperate in order to create sustainable solutions and to be able to evaluate the results for further improvements. However, all business activity should serve a purpose to support a sustainable society. Industrial ecology (Figure 19) practiced within unsustainable business concepts such as production of fossil fuel driven cars or weapons is not consistent. Industrial ecology is therefore a tool, which need *a framework of both ethical and ecological principles* to steer the industrial activity and cooperation in order to support a sustainable development.

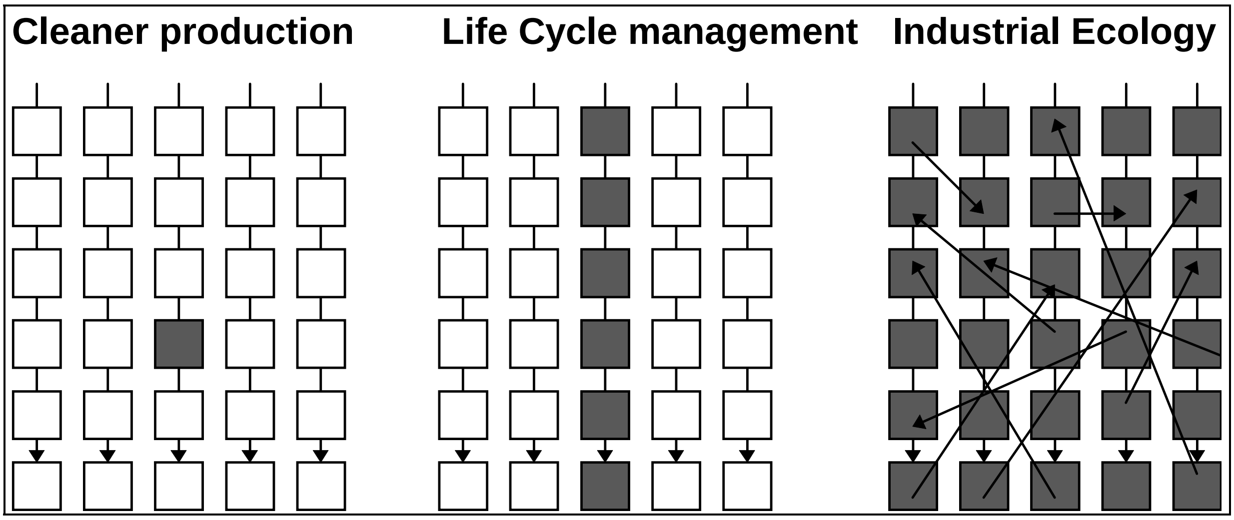


Figure 19 Development of environmental strategies and extension of system borders is typical features to the concept of industrial ecology (Hanssen 1999).

The transorganisational cooperation

The complexity in the society, lead more businesses into co-operation. Transorganisational systems are being developed within the infrastructure for healthcare, transportation and other outreaching functions in society and business as such. These multiorganisational constellations are preparing solutions with the ability to interact with the environment on different levels, to meet the demands from customers, legislation and society in general. This has specially been seen in complex problem solving, as within health and care treatment, but is now also to be found in other more traditional business fields.

The transorganisational systems are characterised by loosely jointed organisations, building a flat structure rather than a hierarchically centralised system. They tend to be rather underorganised in opposite to traditional organisations, and this can be part of the difficulty being a partner in these types of organisational systems (Cumming and Worley 1997). Nevertheless, they are very interesting phenomena in creating product-service-systems. The customers may be served in new ways throughout the lifetime of the product. The business may become a “lifelong companion” to the customer, if wanted, instead of a one-time deliverer of the product/system. This requires from the company the ability of empathy and understanding of the real needs of the customer, and further willingness to fulfill individual customer needs. Only large companies might be able to be “alone”, to serve the customer this way and at the same time be the producer of the total product and service concept.Transorganisational systems of smaller companies which complete eachother, can be stronger and more flexible to meet the demands from customers and the environment in general. When larger investments are involved, financial planners and lawyers should also be part of the system, according to Cummings and Worley.

2.8 The rebound effects in economical, cultural and ethical perspectives

Industrialisation of different services and types of production which for long traditions have been done in the private homes, may loose some of their human essence when they are carried out in an industrial manner. To sell the service concept of arranging birthday parties for kids, is this a sustainable service system? What values does it give the children, and what would make this a sustainable alternative to a non-commercialised party?

However, more efficient results may be achieved through an industrialisation; and technological innovation may contribute to interesting new patterns in communication, work and daily activities. It is a paradox though, that individuals in many situations have to work more to be able to buy the equipment or service which shall give more spare time. This spare time will often be used for additional work, to increase the private income and thereby the possibility of economic freedom. In a society where most activities associated with joy, leisure, excitement or recovery, are connected with some type of material or energy consumption (and economic expenses), implies an enormous challenge in visualising and creating alternative solutions also to these aspects of life.
In product development the economic aspects will always be of major importance in the system we now operate in, but there are many interesting aspects, which can and should be implemented, to move this system into an ecological and humanistic sustainable direction (Max-Neef 1987/1991).

2.8.1 The role of the product vs. the role of the human activity and living

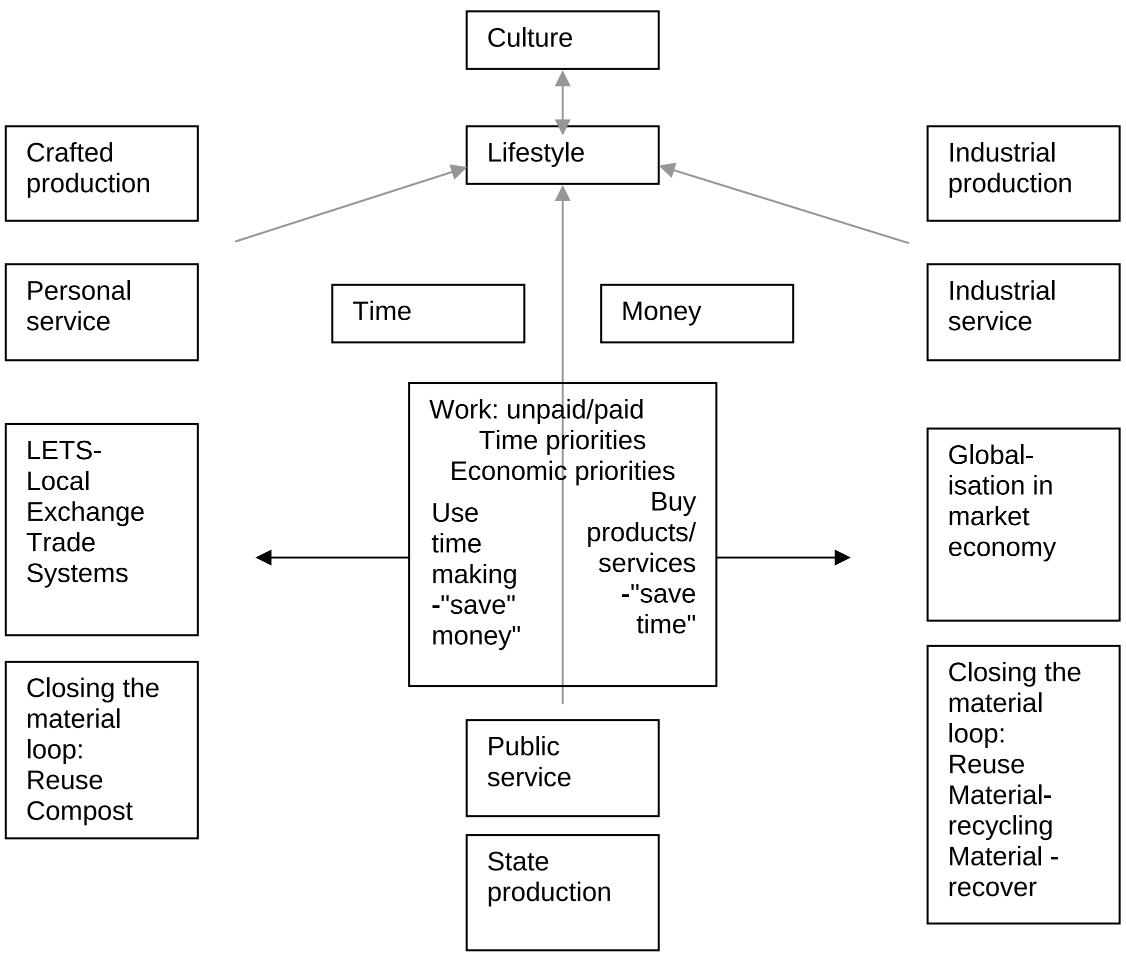


Figure 20 On the one hand, different lifestyles and cultures are changing, depending for instance on the degree of industrialization of production and services offered to the individuals. On the other hand, the priority in use of time and monetary consumption is strongly related to the environmental impact.

The monetary system is influencing our daily lifes in high degree. There has been a rapid change during the last decade in the industrialised world, where it is now given priority to use money saving time, where before time was spend to save money (Ruscoe 2000)(Figure 20). Moreover, many household activities such as baking bread, preserving berries and fruit etc. are hardly an economic gain any more. These final products can now be bought at a cheaper price, produced in an industrialised manner. The choices we are making concerning development of product service systems will have consequences of different character, which again deliver an indicator of how ecological sustainable the concrete solution is.

Ezio Manzini (2002) is discussing the rebound effects of product service systems. The solution itself might be pointing to sustainable values, however the consequences of its lifecycle as influence on other systems and activities is not always evident. Manzini is discussing the consequences of the "well-being" strategy for eco-design products and services and the dematerialisation strategy. He is mentioning how downsized products easier become throw away products, and how a user friendly interface encourages a unnecessarily high user frequency, for example the printing of documents. Advanced communication technology enables individuals to increase their social and professional network and as a consequence travels more physically for meetings, face to face. Further Manzini is discussing the rebound effect of the "age of access" , as definition for modern well- being, the access to services and experiences. The intangible solutions tend to be added to the material ones, connected with a speedy and impulsive life style, both type of use and consumption proliferate (*Figure **21***). Since the services in most aspects are supported by material goods and energy consumption, it contributes to the environmental burdens like the traditional products.

Allenby and Richards (in Charter, Tischner 2001) are presenting many of the uncertainties connected with the introduction of services in the debate of sustainable economy and design. However, they point to the character of some services which may contribute to discontinuous shifts in social behaviour.

Allenby and Richards are mentioning the GNP in developed countries, where 70-80% is founded on service activity. It is therefore not adequate to define service activities as sustainable as such, neither the economy it supports. The service based systems have similar demands for environmental evaluation, and in designing these systems, the sustainable principles, guidelines and criteria must be integrated in the different steps.

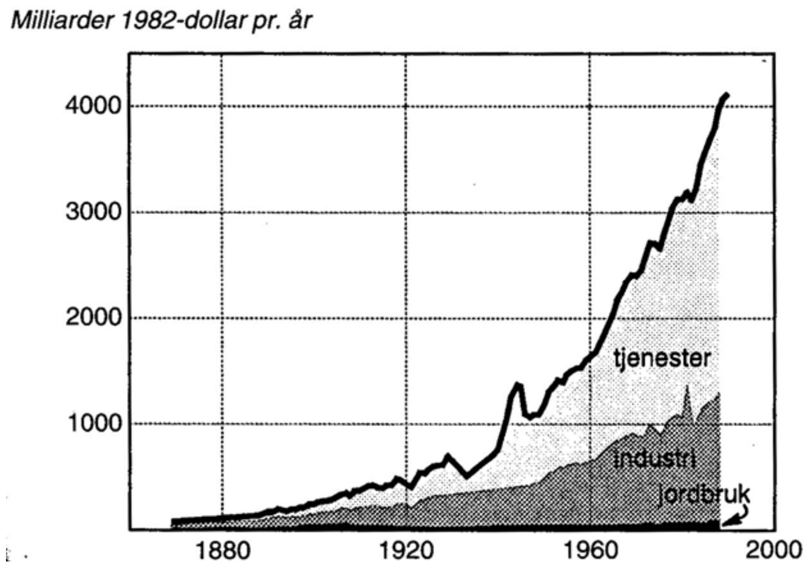


Figure 21 Increase in services (in figure: tjenester) is followed by increase in industrial (In figure: industri) activity but only slightly in agricultural production (In figure: jordbruk) in USA the last 100 years (Meadows et al 1991).

Manzini confronts us with two hypotheses in this context namely that the rebound effects are related to the crises of the common goods, and the disappearance of contemplative time. On the other hand, remedial goods are entering all scenes in life, not actually improving anyone's life quality or user situation. The common goods provide access to functions and experiences to all segments in the population and are goods which are not related to the market activity. Contemplative time is the time for doing nothing, looking at the sunset or making some spiritual exercise, as Manzini mentions. To do things at a slower pace can also have the same affect. The remedial products are in the opposite pushing our activities to a higher speed, introducing many activities at the same time, and so on. Examples of this type of remedial products are the mobile phone, fast, food and TV (inhibiting satisfiers , chapter 2.2, Max-Neef 1992.)

The complexity of systems and how a movement in one area effects the other, is deeply explored by Meadows, Meadows and Randers (1991) in their methodology and system dynamics model , World 3. Their study, however, reveals the difficulty in actually evaluating solutions defined within a limited system in order to map their future consequences. When this evaluation is including human behaviour, there will always be high uncertainty connected to conclusions of such evaluations.

2.9 Research areas

2.9.1 The "vision" as a common direction for change

The Organisation Development field is a relevant source of knowledge in the research for sustainable development tools. It is as well, a field interfering with people and systems in interaction and is obviously a matter of high complexity.

From the theory and practice in this subject the use of *Vision* as a guiding star for direction of change is also described in T.G Cummings and C.G. Worley (1997). Describing a vision is the second step in a change process (AppendixIII). The members of the process describe their organization how they would like it to experience their organisation in the future. It shall provide a valued direction for designing, implementing and assessing organizational changes.
The vision can have an affect on the commitment to the process and inspire the participators to move in the defined direction. However, a too ambitious or unrealistic vision can have the opposite effect and depress the individual motivation. A successful vision can bring meaning to a process or place the further activities into a larger setting.

The process for developing a vision demands creative and intuitive work processes, which are often not valued as high, or taken as serious as rational and analytical methods. This may lead to the consequence that little time is given in the daily work situation for this type of processes, and the leaders must therefore provide specific settings, such as workshops off-site to invite the members in different thinking (Cummings, Worley 1997).

The process shall result in a *Vision Statement*. This statement on an organization level may include a mission, valued outcomes, and valued features. Finally, the vision statement includes a metaphor or slogan which brings energizing commitment to the change and thus is emotionally powerful.

The mission includes the reason for the existence of an organization and the major strategic purposes. It may also include the target customers, markets, principal products or services, desired public image, values, priorities and competitive strengths.
Valued outcome can be the specific performance of a company and the human experiences, like employee's satisfaction, development, safety etc. These values can be comparable with the goals in an OD change process.
The valued features are the future desired characteristics of the organization to achieve the outcomes. It may be seen as strategies to reach the goals.

2.9.2 Qualitative evaluation introduced in an early stage of the development process

Early concepts
As mentioned before, the initial phases in the development of new solutions are crucial to the results. Evaluation processes during the development are therefore introduced in some aspects these phases concerning e.g. environmental impact in terms of somewhat quantitative analyses (chapter 2.1 and 3.1). However, if the project is a new development and is not based on details of a reference system/product, qualitative types of evaluation seem to be needed in the early design process.

If projects could be evaluated on an early conceptual stage, the final environmental and social performance would possibly be of higher quality in the final result. This evaluation would be of a more qualitative character, since the detailing is not on a defined stage in this phase.

As described by Richards and Allenby referred to in Chapter 2.8, product service systems are not necessarily more environmental friendly than single product solutions. When eco-innovation is promoted as a strategy towards sustainability, the switch towards services might be even harder to evaluate in terms of environmental impact, in comparison with single product evaluation (such as LCA). Also the methodology, which involves a reference product seem to be unsuitable considering the changes from being a pure product and its lifecycle to supply the product with a service (Stevels et.al 1999). An evaluation of eco-innovations should include all relevant issues for companies, consumers and society, which means human labour conditions as well. These complications lead to difficulties to evaluate new solutions during the design process, but also after the new solution has been introduced to the market (Mo Jakobsen, Wigum 2001).

The qualitative carrying idea of the product system concept should be evaluated in terms of how it is an answer to a problem and a need in the context of cultural, social, ethical and economic premises, and in concert with sustainable values and principles. The consumer- and user focus in industrial design brings behaviour, lifestyles, need and consumption factors into the early phases of the design process (Sherwin 2001) and these are therefore objects for evaluation on this stage.
There is a challenge in the distribution of the environmental data and presentations of assessment results. The information submitted to a design process must take into account the practical and specific need of knowledge, which the development team and designers have.

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www.kafus.com/profile/corporate_background.html

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www.trianglegallery.com/exhibits/roughcuts/index.html

3.0 Exploring the existing design approaches

As presented in previous chapter the perspective of the design task is seen in different levels which are: the product level, the system level, and then the connection to society and global issues.
This chapter will similarly present existing design methodology for Factor 10 design, which is integrating a global evaluation, further methodology for system design with a user perspective is presented and finally methodology for the product level. The single products are seen as important even in a global perspective, and the other way around, the global situation is depending on all the products and human activities added together. In his thesis Chris Sherwin (2001) has defined many different types of approaches in Eco-design by starting with Design for environment and reaching Radical Eco-innovation and Design for sustainability.
An innovation may appear on the product level as well as on a system level, however, the invention must make entrance as a solution in the market and become adapted by the society in order to become an innovation (Denning 2004). The last section of this chapter will therefore include some perspectives concerning the business strategic level, including some views on how to establish Factor x projects.

Eco-design methodology vs. environmental analyses
The different environmental analyses can contribute with important inputs to a design process. The design process itself, however, is of a very different character than the analysing methodology; more organic and unpredictable in some stages, which is necessary when creating new products that the market has not seen before. This chapter will not include the methodological basis of environmental analyses. Nevertheless, most of the Eco-design methodologies include simplified methods for eco-analysis in some of the steps towards a new product.

3.1 Design in different dimensions and degrees of complexity

Eco-design has evolved with different attributes in the mechanical engineering profile, and in the humanistic aesthetic profile (*Figure 22*). The environmental issues are, however, complex joint-problems and are depending on the accomplishment of both approaches.

The eco-design approaches presented so far in the literature are to a high degree following the engineering approach with use of a reference product. This type of approach is not inviting for new development, but rather improvement of existing solutions and supporting system (eco-efficiency, see ch. 1.2). At the end of the 1990’s and the beginning of 2000’s, new methodologies appear and are focusing on eco-innovation. These methodologies are putting weight to the human perspectives in the design team and the total business context of the new “innovation” as well (Sherwin 2001).

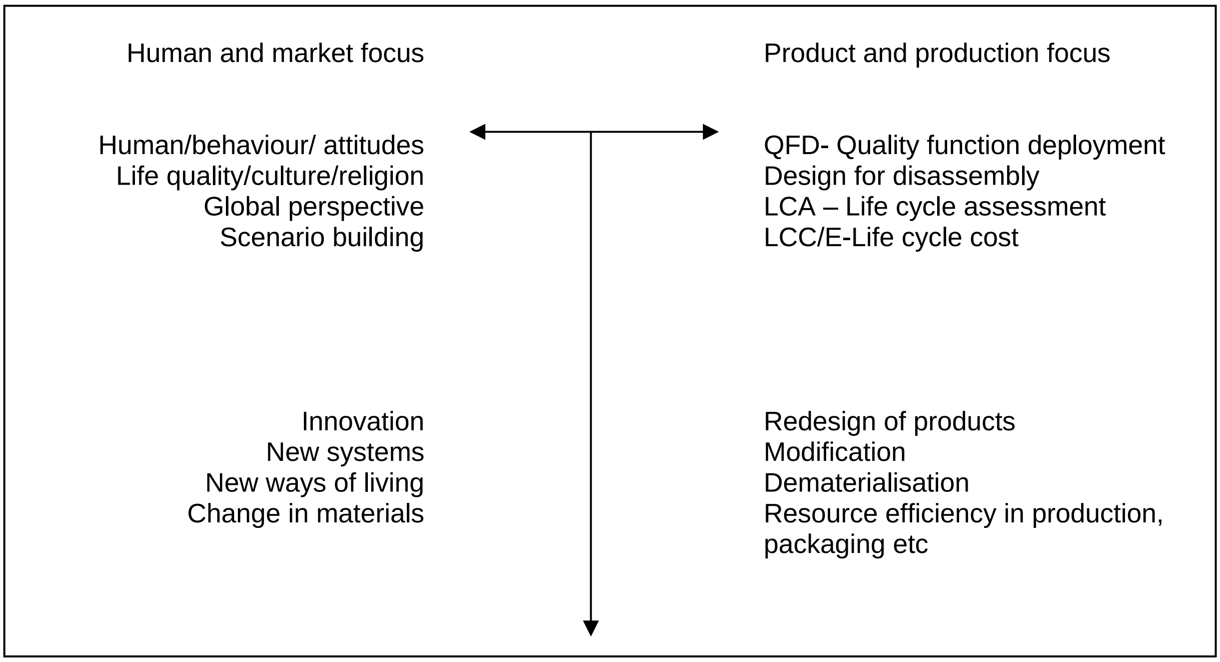

Figure 22 Two disciplinary approaches towards eco-design; the humanistic and the material (Hanssen, Wigum 1998).

The development of new product solutions can also be seen in a wider framework, on a system level and in a global context (Table 9). The freedom within the framework of a new development is deciding whether a holistic approach is appropriate or necessary to solve the design task. A suitable methodology should then be considered in the light of the scope of the project. The design process can be composed of different methods for the conceptual stage (idea generation) and the following specification (detailing) of the chosen concept (Lerdahl 2001).

Level of connection	*Known "methodology" on the different levels*
Global Level "Factor 20 per capita, involving lifestyles through lifetime living" society, culture, economy, and world nations	**Conceptual stage**: Different world views, ideologies, religions, politics, future perspectives (e.g globalisation) **Specification Stage**: Legislation and trade organisations are making specific rules between nations. This may influence decisions in the design process on the system and product level.
System Level "When serving the user is a part of the product" personal lifestyle, company service concepts, transorganisational busines	**Conceptual stage**: Backcasting Vision play, Visions in product design (VIP) **Specification Stage**: DOS, Service system design (Morelli 2001)
Product Level "Human values expressed in products" user experience, product solutions	**Conceptual stage**:Design Oriented Scenario (DOS), Visions in product design (VIP) **Specification Stage**: Usertests, Tjalve/Eckels…, methodology by United Nations Environmental Programme UNEP, Danish Programme for Development of Sustainable Industrial Products UMIP, etc.

Table 9 The table shows how each level includes a conceptual and specification stage in the design process, and are connected across the levels in some aspects.

There are a number of evaluation methods and systems of eco-indicators from the field of industrial ecology (Graedel , Allenby 1995). These are, however, methods of mainly quantitative character and they may therefore function isolated as input to the analyses in the introduction phase of the design process, or detail information in specific decision making concerning e.g choices of production processes, treatment of surfaces etc. These types of analyses can also be describing the macro-systems and the proportional relationship between various impacts and flows (Table 10).

Level of analyses and measurement	*Known methodology on the different levels*
Global Level "Factor 20 per capita, involving lifestyles through lifetime living" society, culture, economy, and world nations	**Factor 4, 10, 20:** Extended LCA? Xergy System dynamics
System Level "When serving the user is a part of the product" personal lifestyle, company service concepts, transorganisational business	**System, eco-effectiveness** : Extended LCA/LCC, qualitative analy. MFA, Material Flow Analysis/SFA, Substance Flow Analysis, Regional metabolism
Product Level "Human values expressed in products" user experience, product solutions	**Product , eco-efficiency :** MIPS, Material Input Per Service MET-matrix, Materials, Energy and Toxic emission LCA, Life Cycle Analysis/LCC, Life Cycle Cost, qualitative analysis

Table 10 Simplified overview of quantitative evaluation tools on different complexity levels.

3.2 The pre- and initial preparation phases for design project

The planning phase of a design project is part of the strategic work in a company. The decisions concerning what to make and for whom are strategic issues influencing the entire company activity (Cummings and Worley 1997) (Verganti 1997). At the same time, the work in these phases is not of high cost, however, wrong decisions in this stage can lead to high expenses in the later stages in order to correct the course of development (Figure 23).

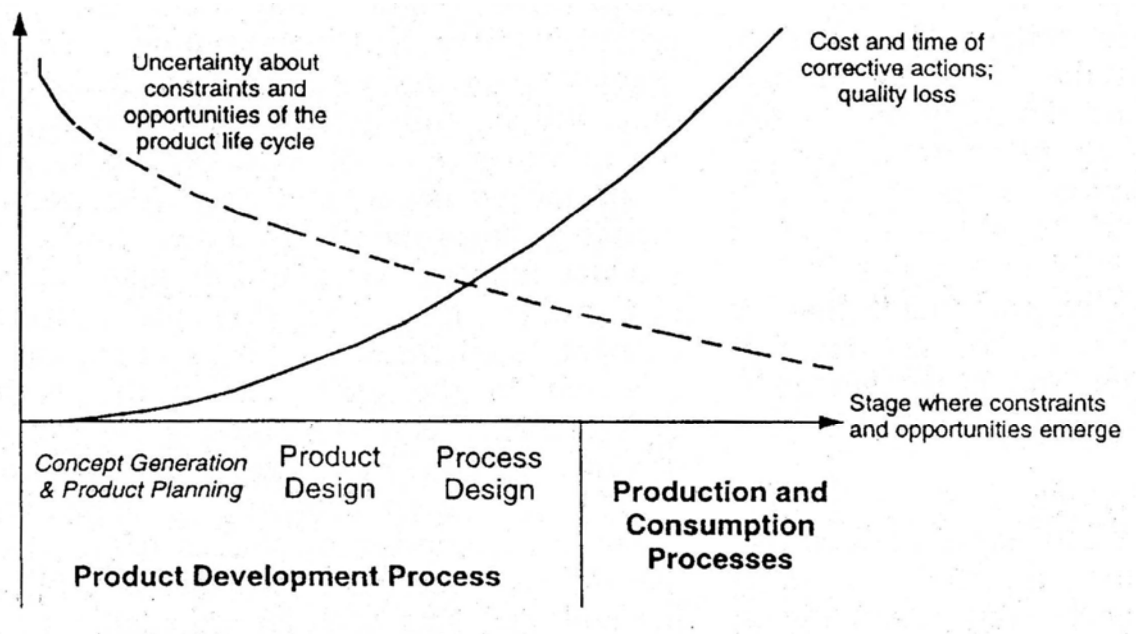

Figure 23 The graph shows that a design project favourably should make the right decisions in the initial phases, where the cost is low for corrective actions and the opportunity of influences high (Verganti 1997).

In terms of sustainability the pre-initial phases are also crucial in terms of major decisions, which determine the further steps of design and development. Further, it is a challenge to complete the development process and maintain the core values in the project all the way to the final results. For projects which involve a number of stakeholders in a non-hierarchic system (transorganisations), clear visions and goals may be necessary in order to guide several steps and activities in the same direction.

Vision as a tool for value expression

The Norwegian interior and industrial designer Odd Thorsen and his design bureau have specialised in managing the process of composing design programs and design manuals for different product systems. Thorsen was also the responsible designer in the pre-project and the report of suggested framework for the Lillehammer Olympics '94 (chapter 8). In 2002 he edited a book describing a common design profile concerning the wood- industry in Norway and its end-products (Figure 24). Thorsen is using the term *vision,* shaped as a literary sentence, which carries the main values for the project. The vision has the role as a directory for further decision making.

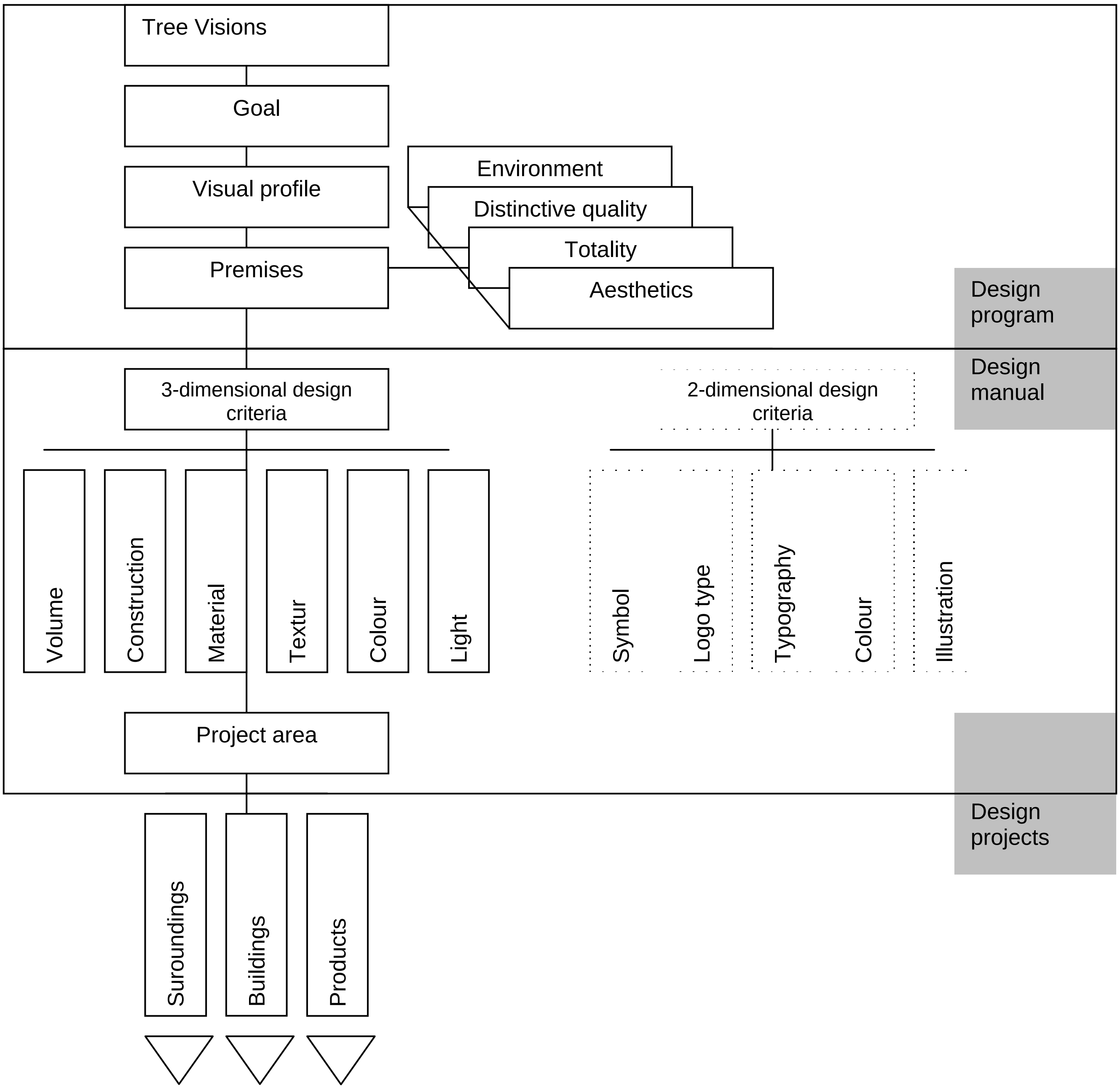

Figure 24 The design management might involve the development of a design program, a design manual and finally specific design projects (translated from Thorsen et al 2002).

Thorsen and co. redefine the approach and constrains for of every new system design task. Every project needs to be evaluated specifically and will contain a certain choice of ingredients depending on the character of the project. However, common for all the projects is the role of the vision as a value carrier through the project, leading the goals towards a specific direction.

Project management

Thorsen is performing a Need analyses (pre-project) for projects before the main project is initiated (Figure 25). This is common practice for larger projects involving long term strategies and/or extensive design work.

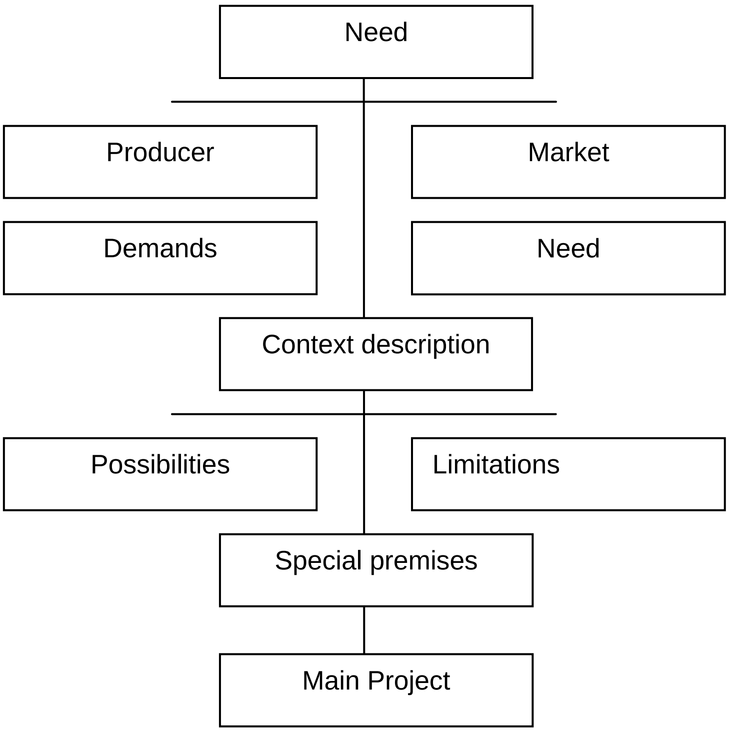

Figure 25. A need analysis is executed before the main project is initiated (Translated from Thorsen et. al 2002).

3.3 Factor 10 design

The factor 10 concept is pushing the perspective even wider, from product, system and services, towards society development, infrastructure, urban planning and political priorities.
From a global view in terms of energy and resources and the total amounts available, every local decision should be evaluated based on the idea of fair-sharing. This is obviously an utopian concept, however, there is not enough resources for the total global population to have the same material consumption as the Western World today, and therefore this ideal is fronted by several research institutes (see chapter1.4).

3.3.1 The organisation and administration of factor 10 projects

Preparing the factor 10 project teams
Leo Jansen[3] started the interministeral programme in Netherland 1991, by making interviews with people he knew would be important for this major project he had planned, concerning sustainable technology development. These were key persons coming from industry, politics and science. His aim was to create a preparative committee consisting of all different types of people. After setting the premises, founding the people, he composed the different working groups, and the group of references. Jansen was careful finding the “champions” for the working groups of the five different themes in the project (water, housing, transportation, food and chemistry). The leaders, he needed, should be creative, administrative, have authority, be trustful and open. Leo Jansen emphasized the importance of the fine work *ahead* a project. Creating the right atmosphere and conditions to support the project work demands a clear strategy and many good connections.

[3] Solveig Steinmo (Tomra ASA), Martina M. Keitsch (NTNU) and Kristin S. Wigum made a personal interview with Leo Jansen at TNO in Delft Netherland, autumn 2000. This section is based on his answers which were written down in notes during the interview.

In the personal interview with Jansen, he gave us some of his empirical key points to succeed with this type of developing projects:

- The choice of people is very strategic; don't choose the "believers[4]"!
- The economic interest is always strong and must be taken into account in the process from the beginning.
- People must be involved before start.
- Important not to base the actions on power.
- Important to find the real drivers and personal goals to make every person engaged in the project.
- Turning from problems to challenges.

More debate and more openness should be a part of involving people in the certain projects.
Peter Stiring was the researcher who developed the backcasting methodology by making people imagine new solutions, which built on sustainable technology in future scenarios.

The creation of a new business is part of the marketing- and economic disciplines. Working out a business concept, which has ecological and economical benefits, demands for people representing these different fields, and perhaps in addition, more untraditional fields too, to create the spirit, knowledge and working capacity for businesses of tomorrow.

3.3.2 Future scenario in product and system design

To present solutions in a future perspective can give a detachment of to days lock-in problems and therefore reveal new and promising ideas. However, it introduces the challenges of the future such as higher population and restraints on resources, which provides for a new context for solutions and therefore more realistic in the aspect of sustainable goals.

Forecasting
Fussler and James(1996) present some scenarios as a framework for future eco-innovation. These belong to an EU- project and are only focusing on European future conditions. Prognoses and statistics were used as background information.
Nevertheless this was a utopian presentation as well, since the global networking is increasing, production processes are spread all around the world within one company, and people are moving from one continent to another to a larger degree. In the design perspective the desired and solution oriented scenarios seem more natural.

3.3.3 The development process

A major project in the Netherlands initiated by Leo Jansen, was completed in 1998 and presented methodological by Paul Weaver et.al in the book *Sustainable Technology Development,* 2000.
The project included five areas; housing, food, water, chemicals and transportation. Five ministers and their governmental departments were involved in the project.

The project developed a methodology including these steps :

Step 1. Strategic problem orientation
-theme
-areas where more information is needed
-info collection

Step 2 Sketch of a sustainable future (2040)
-"out of the box" (wished/desired future)
-orientation, future vision

Step 3 Backcasting (Figure 26)
-using the future as your starting point and reasoning backwards; trends which must be broken in order to create changes
- new patterns which must be established from today
-drivers

[4] Leo Jansen meant by "believers", the people who already are strongly focused on environmental issues. To have a holistic approach the project team should have interest also for other perspectives.

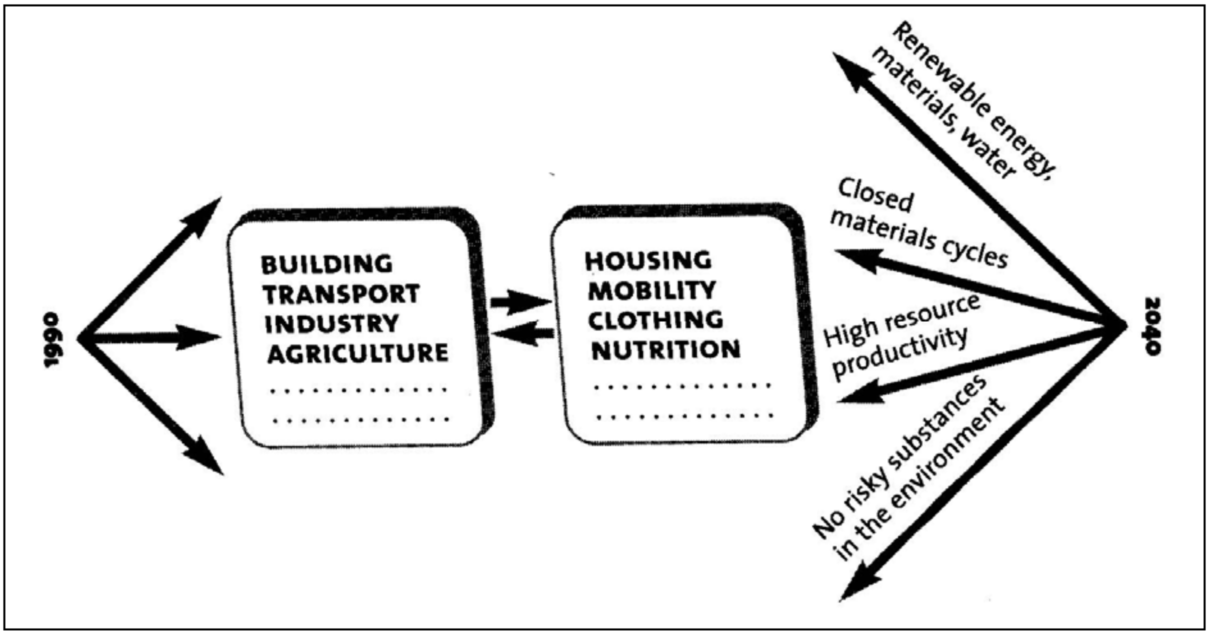

Figure 26 The Backcasting approach (Weaver et al 2000).

Step 4 Five solutions are selected and analysed in terms environmental improvement potentials
-possible company contributions
-environmental benefits

Step 5 Further development of the best solution(s)
-possible innovation worked out in clearer detail
-short-term and long-term possibilities are presented

Step 6 Co-operation and integration
-joint ventures

Step 7 Realisation and implementation
-starting off development processes

3.3.4 The factor 10 analyses

The analyses are rougher and more focused on the totality and the relationship between different aspects in the society, and also the connection in a more total system (Illustration 9 and Illustration 10).

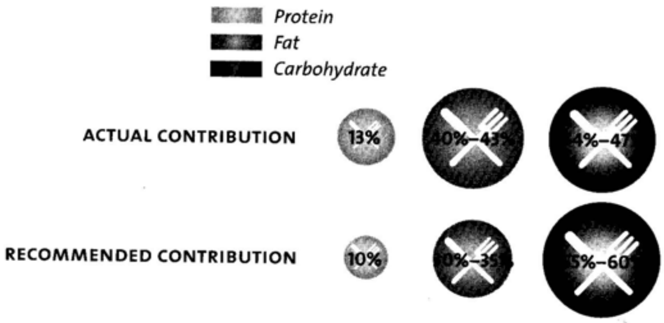

Illustration 9 The analyses in the work of food, included the existing situation and the recommended consumption in terms of health perspectives (Weaver et.al 2000).

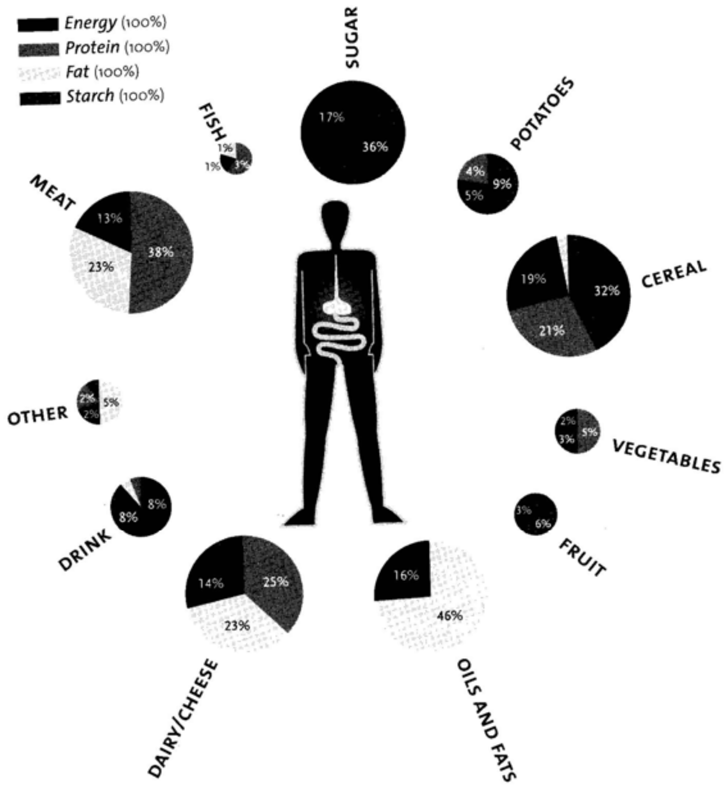

Illustration 10 The total view of nutrition eaten by the average Dutch gave a picture of the energy and resource consumption in comparison (Weaver et.al 2000).

3.3.5 Factor 10 in company relation

The research projects, initiated by researchers and educational institutions are approaching the design process with ideal conditions and in most cases free from business organizations' rigid structures, economic criteria and so on. The projects are usually focused on the process and methodology, however, not so often in relation to traditional company structures and petrified thinking models. The development projects of the latter character and also the product service system projects are interfering with company visions and strategies. The management of such project, should be connected to the CEO, Chief Executive Officer (managing director), and be conscious about the future company goals.

3.4 System, Service, and Product design

3.4.1 The content of system design

System design is an area professionally developed by other fields such as logistics engineering, and also more theoretical fields like mathematics and logics. System theory is a source for knowledge also for the design discipline. Even if this thesis will not enter this area in theoretical detail, there is behind the Factor 10 concept an implicit and explicit need to extend the system boundary for single products. Architects and designers have worked with system design continuosly, but on a practical and perhaps more intuitive basis. Courses within system design for designers have in the last years been introduced in some design curricula, for example in Aalborg, where they also develop a stronger theoretical basis concurrent with the course.

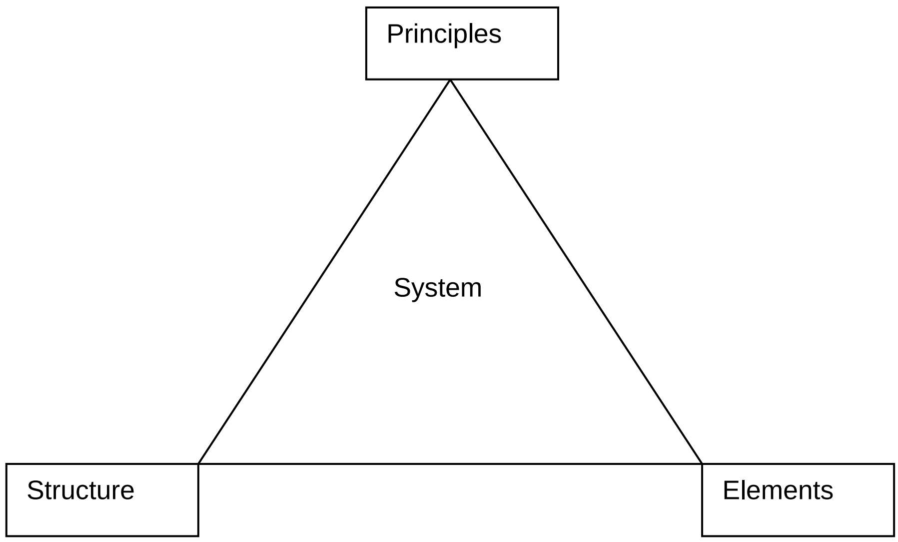

Figure 27.Stockholm, Marianne, Aalborg University is operating with this model for system design.

A system is by Stockholm (Figure 27) defined as *elements* of objects, activites or functions, which are related to each other through a specific *structure*, or positioning. The relationship between the elements and the created structure is based on specific technological or organising *principles*.

Material Input Per Service
Material Input Per Service, MIPS is a method for analysing the environmental impact expressed in terms of total material input in relation to the actual or potential units of service (Weizâcker et al 1998). Life cycle data is the bases for the evaluation; however, the presentation of the results is related to the actual unit of use. This evaluation can connect different Life Cycle Assessments of products together and present the result with focus on user activity, rather than on the single products and its systems. This is an advantage in terms of actual user related environmental impact.
LCA is also operating with the analyses of a "functional unit", but this unit is defined in a rather theoretical way on the premises of the product.

The methods serving to analyse the existing or suggested products and systems is a step in the direction of creating awareness and knowledge of the *environmental problems*. Improvements through new solutions demands for different types of knowledge. The natural principles of sustainability, design and manipulation of product life cycles and appropriate use of materials are important issues in the development of alternative solutions to the failing ones of today.

3.4.2 User analyses in service design

Use-case study
The design of product service systems is like traditional product design switching between the analysis and information collection and the designing of new concepts, details etc. (Figure 28)

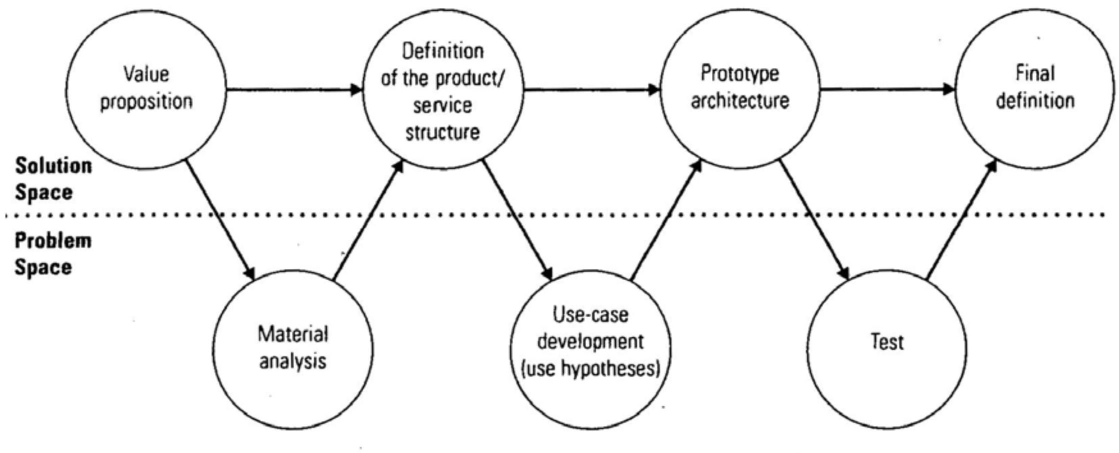

Figure 28 Nicola Morelli (2002) is in this model conceptualising the switch between analysing and implementing results into the new solution of a product service system.

To focus on the user activity within the chosen boundaries, can be done by the observation of existing systems. For new systems the sequences of the user activities can be theoretically discussed before testing. Ass. Prof. Nicola Morelli (2002) is describing the methodological challenges for both designers and project managers in designing product service systems. He is suggesting framework of social construction and is referring to Bijker (1995) to find criteria for the technological framework. Wiebe Bjiker is describing social construction and linking the micro stories of new technology solutions to the macro structures in society.

Morelli is introducing a flow-scheme which connects the different type of activity, and if a product or service is involved. The flow scheme is then composed by different visual keys (*Figure 29*).

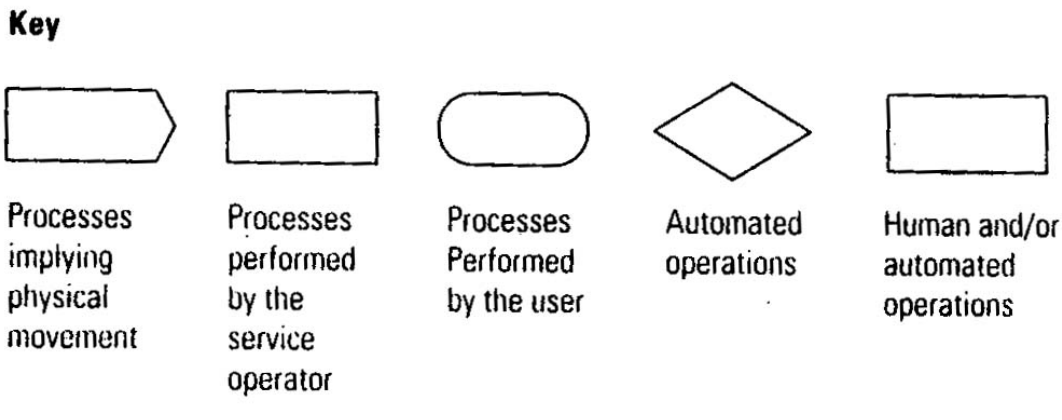

Figure 29 The keys used in the use-case study scheme (Morelli 2002).

This methodology is a sequence and frequency analyses on a less detailed level than what is often performed in a traditional design process developing and designing a single product. However it is not replacing the more detailed analyses, rather mapping the connections, context and framework for the more detailed activity and interaction analyses.

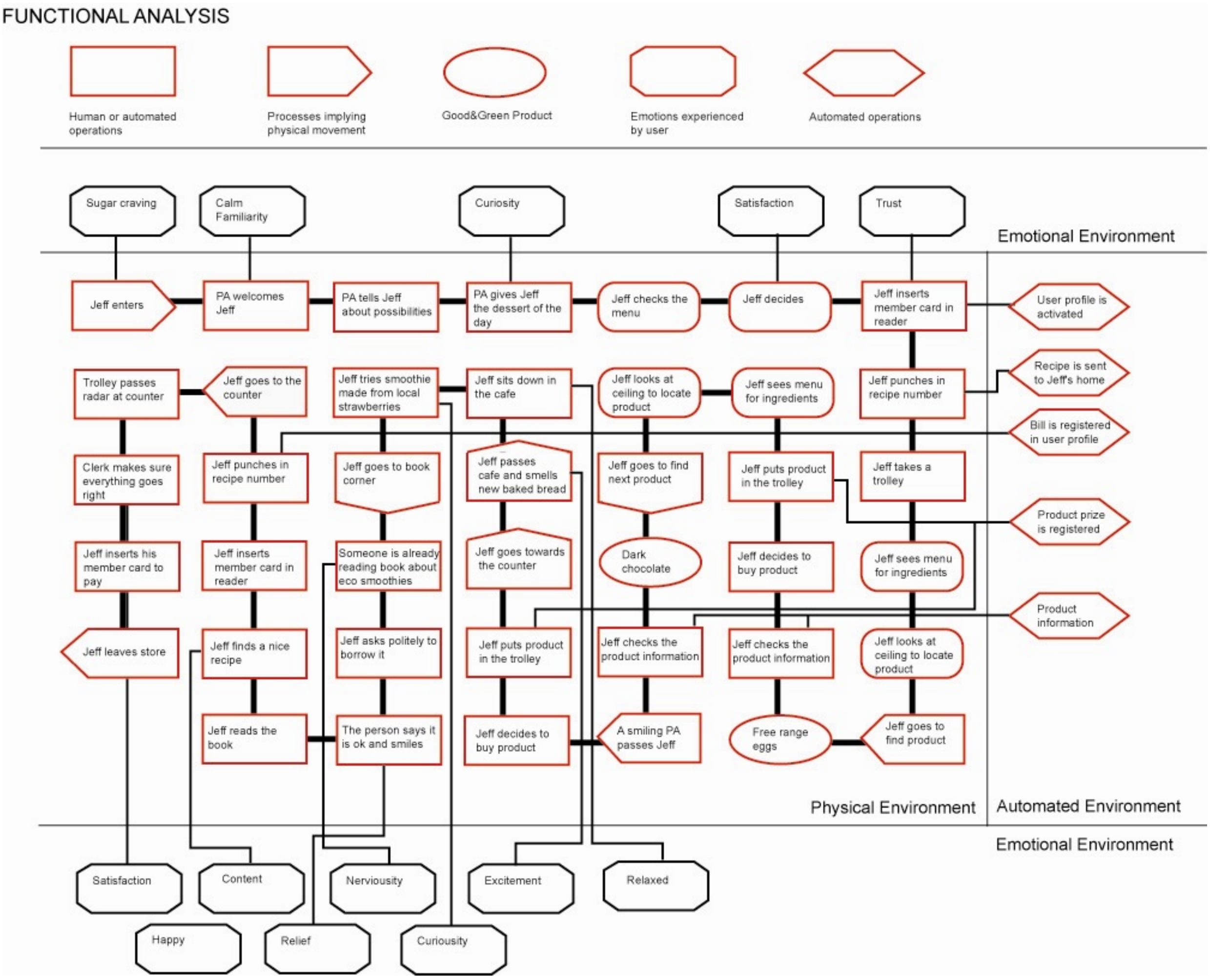

Figure 30 From student project in Eco-design course at department of product design Engineering, spring 2003 (ch.10) Group 1: R. Dehli, Nesbakken, Lee Mei Chean, O. Svensen, G. Pedersen, Breen.

One of the groups in the Eco-design course at department of product design Engineering, spring 2003 presented in their use of Morellis use-case study a additional element, namely the atmosphere and type of experience which was desirable in the different stages of the customer sequence in shopping situation (Emotional experience) (*Figure 30*).

3.4.3 Design oriented scenario

Sushouse – Strategies towards the sustainable household, EU project (1998-2000) developed different user scenarios for transitions to sustainable households. It focused on “shopping, cooking, and eating” (Figure 31), “clothing care” and “Shelter”. Design teams in five European countries participated and worked on one of the chosen themes (Quist 2000).
A method, which was developed, Design oriented Scenario, focused on the user context and interaction with new products and service systems. The concepts were later discussed with potential future users and evaluated in terms of potential improvement in consideration of today’s solutions. The Design Oriented Scenario was executed through three steps(Bras-Klapwijk, Knot 2000):
.
Creative workshop I:
Stakeholders are invited to an idea generation for factor 20 solutions in 2050.

The project team is arranging and sorting the material for development of different scenarios and belonging innovative products and services which promote the content in each scenario.

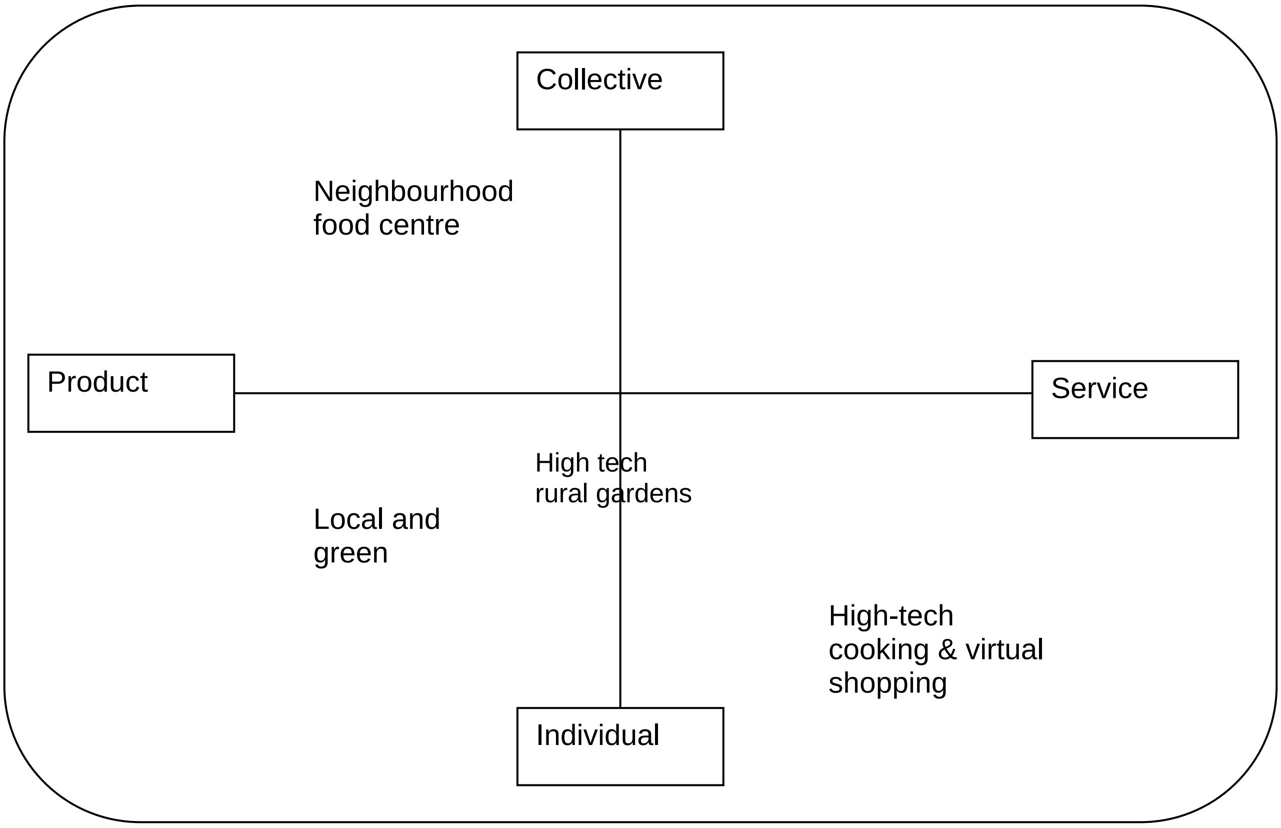

Figure 31The scenarios where based on different perspectives in terms of value priorities and technological application. (Vergragt et al. Sushouse CD 2000)

The scenarios are then analysed within three categories:
A. Will the scenarios contribute to a factor 20 development within the next 50 years?
B. Which economical benefits and business opportunities do they present?
C. How acceptable are these solutions for the different consumers?

Workshop II : The stakeholders from the first workshop are re-invited. This time the participants shall value the possibilities for implementation of the best solutions and concepts.

Vision in product design
Paul Hekkert introduced in 1997 the VIP methodology. This methodology is disassembling the existing framework and context of a product, in order to rebuild the product setting and therefore achive new product results. This methodology is, however, not discussing the priorities of values in the new product context. The visions introduced in the methodology are images of metaphors or analogies and inspirational visual elements as such.

Tailor made solutions
HiCS, Highly customised solutions (2001-2004) is a EU project within the Growth programme (Van Sandick 2002).
This project studies, in close co-operation with several companies, the possibility of designing solutions that are specificially suited for different user contexts and needs. The theme of the project is the meal “Good food to everyone”. A methodology is discussed and tested, where the quality of communication between the different stakeholders is of high priority. Visual tools are used in order to avoid misunderstandings to at least some degree. The methodology is also introducing visual tools for non-designers to become more active in the idea generation and development process.

3.5 The product level

3.5.1 The engineering approach based on a reference product

Many methodologies for the product engineering approach are based on the analyses of a reference product. The results from the analyses direct promising strategies for improvement and redesign of the existing solution. This type of methodology includes favorably the methods of Quality Function Deployment (QFD) /The House of quality, where the product functions and product elements are decomposed and compared in terms of production and usability etc. The weaknesses in the product are then highlighted as special objectives for improvement. This methodology emphasizes the phase of analysing as introduction to the development.

In Mørup thesis “The design for quality” (1993) the product is represented with product qualities experienced by the different users , Q-vectors, and the material qualities placed in the product, effecting the production, logistics, service efficiency etc., q-vectors. These two types of qualities are related to the different life phases of the product and the related activity from the user or physical process.
Andresen and Støren (1993) connected the methods QFD and the Q/q-vectors to an analysing method “Learn to Know your product”. This approach is also based on a reference product and deep studies of its elements, however, seen through the total product life cycle, from development and production, to the final disposal.

This analytical approach was tested and placed into a more total product development process for SME’s, by Mo Jakobsen (1995). Her methodology, the PCD-approach (Product Concept Development) is also emphasizing the initial phases of the development process, but with the focus on the development process as such and its potential for improvement.
Mo Jakobsen is introducing the 10 dimensions in the product development as directors for criteria and specification during the total process. The dimensions are: the Functionality dimension, the dimension of Market, the Production dimension, the Design dimension, Usability dimension, the Security dimension, the Environmental dimension, the Additional dimension and finally the Product life dimension. The dimensions are given varied priority depending on the product type and task, and they are given attention at different stages in the development process. The PCD-approach is acknowleding the Design dimension as being the aesthetical specifications and standards for approval.

It is important to distinguish between the *integrated product development* methodology and the design methodology as such (Hein, Andreasen 1985)(*Figure 32*). Whereas the first is involes a number or management issues and organisational perspectives in order to coordinate the functions in the company, the latter is occupied by the synthesis of a new product solution, answering the vision and criteria specified according to strategies and desires for the final product result.

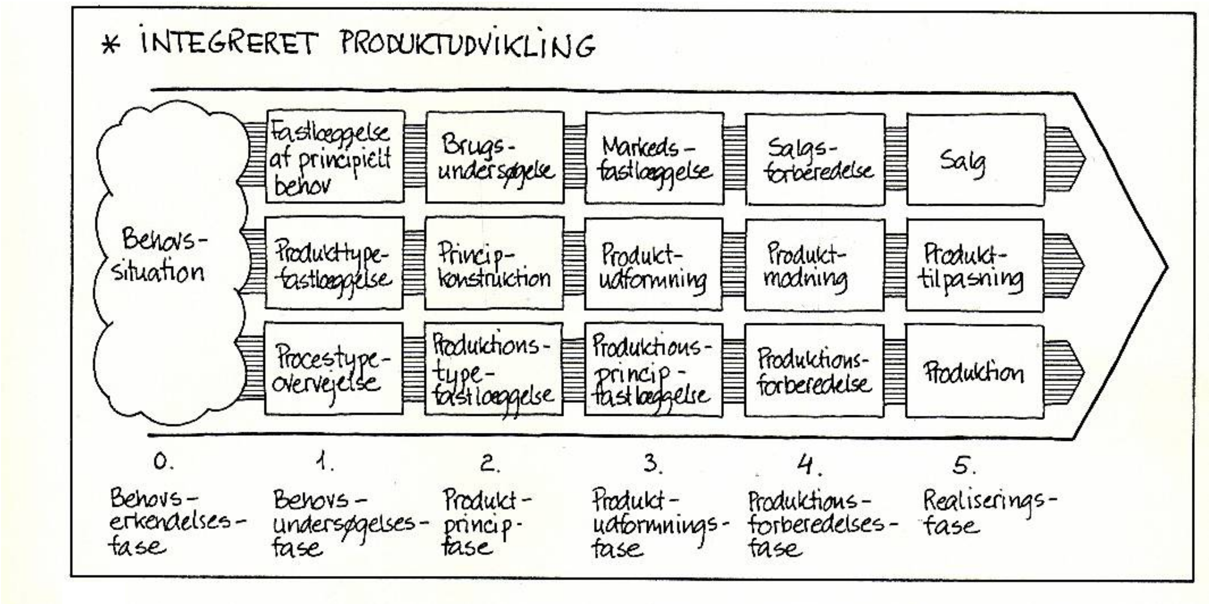

Figure 32 Integrated product development, (Hein, Andreasen 1985). The marketing function, design function and the function in the company are corresponding throughout the development process.

3.5.2 The industrial design methodology based on inspiration from product users and market trends

The industrial design methodology is based on different development philosophies (as presented in ch. 1 and 2), which are often taught to design students on a more open basis. The designer is also trained to give shape to the design process depending on the character of each specific design task (Stoltermann 1994). The methodology may be based on engineering approaches like the methodology of Tjalve (1976), however with a user-centred focus including aesthetics and ergonomics as main issues, adapted to the product scope definition. The idea generation, choice of expression and product principle development is often based on a manifold of information gathered from competitors and other objects of inspiration. Rather than analysing a reference product, the analysis can be based on user observations, study of market segment and the total product specter, social trends etc. The work of an industrial designer might therefore be of a more strategic character in terms of business strategies and communication with the market through their products and product values. The industrial designers approach is systematic in a flexible and holistic way (
Figure *33*) . The object is designed both “from inside out and outside in”.

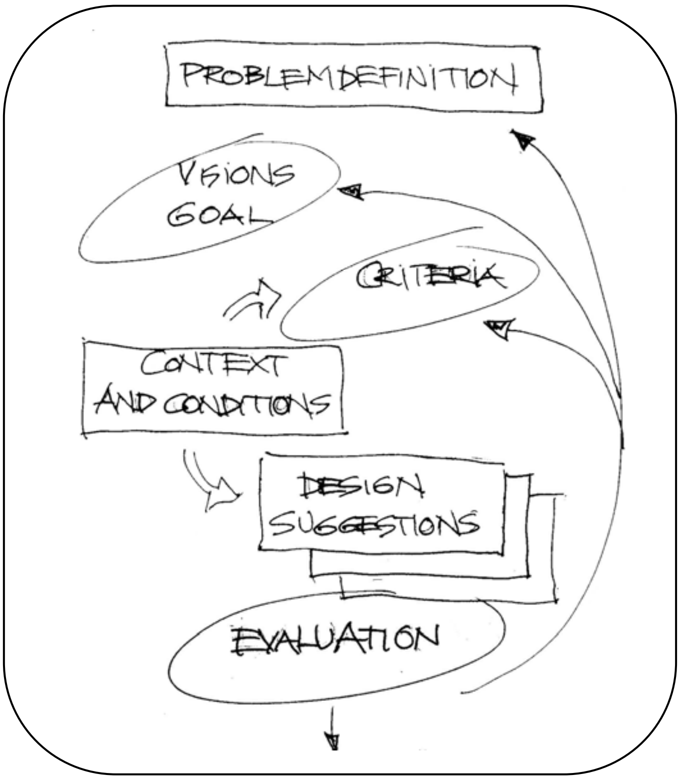

Figure 33 A general model of the design process (drawn after Wikstrøm 1994 based on Rosell 1990) taught at the industrial design education.

3.5.3 Redesign with environmental considerations

Life Cycle Assessment can be executed as an analysis on different detailed levels to indicate the impact areas caused by the product and its system. It is a complex work and should be executed by experts if the analyses shall be used in open documents. The ISO-standards 14040-43 are describing the process of this type of analyses. Superficial analyses of design concepts or existing products can be done by non-experts, with tools such as the method Ecoindicator 99 (Goedkopf, 2000, Prè consultants, Netherlands). This method is presenting pre-made indicators for different materials and processes, energy and end of life scenario. The impact is compared to the average consumption per year per European citizen.

A general comparison of single products and their impact on the environment shows that the phase of raw material extraction(P1), preparation of raw material (P2), transportation of products home to end user, the use of the product (P6) and the disposal (P9) of the used product are the worst (Figure 34)

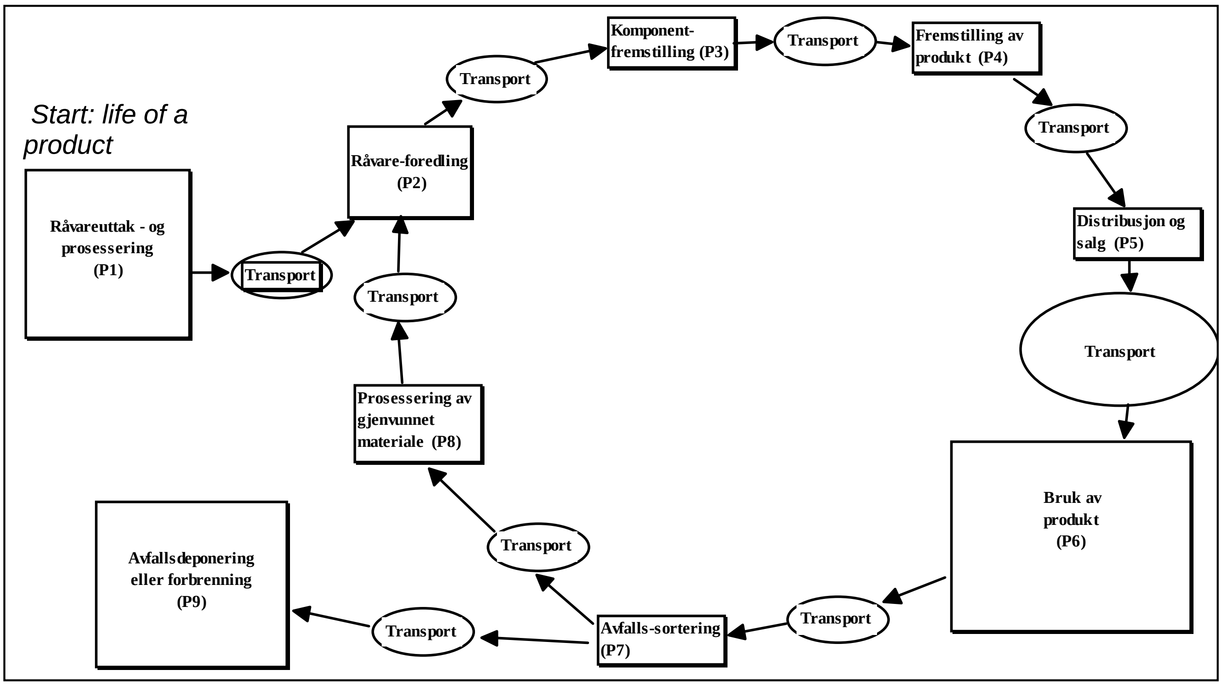

Figure 34 Schematicalpresentation of a life cycle of a product system, with a rough estimation of the size in comparison with total environmental impact for every step in the life cycle (Hanssen, Wigum 1998).

The life cycle thinking of the product in the design process is a part of the important characteristics of an Eco-design methodology (Tischner 2001)(*Figure 35*). End-of life issues such as repair and disposal have been evaluated in traditional designing as well, however, in Eco-design methodology the purpose is clear, namely to reduce the environmental impact from the product and product use as far as possible.

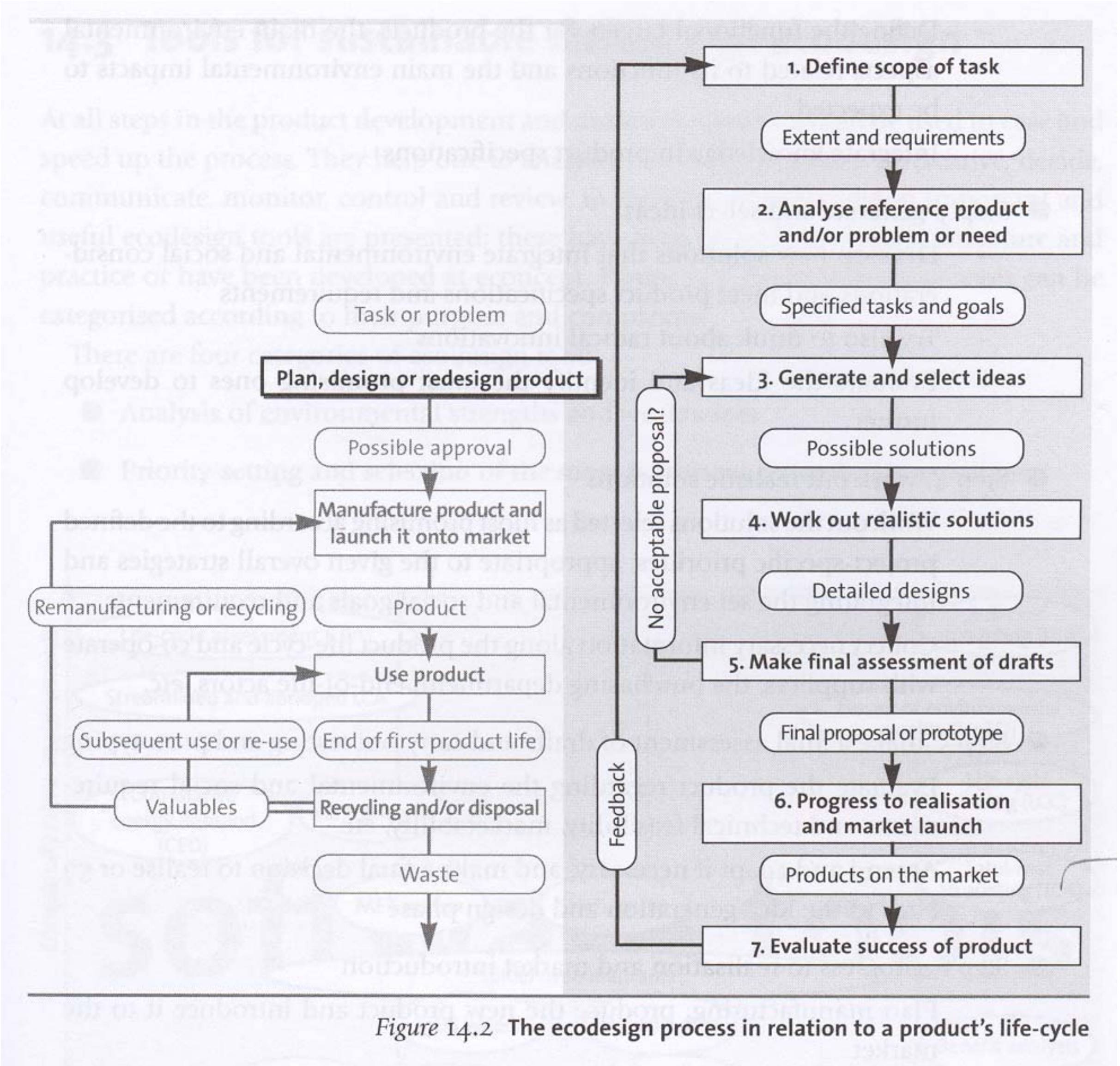

Figure 14.2 **The ecodesign process in relation to a product's life-cycle**

Figure 35 Tischner presents the difference and parallel between the designing process and the product life cycle (Tischner 2001).

The following examples are illustrating typical approaches in Eco-design methodology concerned with the product level and based on the reference product- strategy.

UMIP, Danish Programme for Development of Sustainable Industrial Products

A Danish national initative introduced in 1996

This project included the study of the position of eco design in a company, designer's working tools, environmental specialists and project managers approch. A analytical tool was designed, as a method for simplified Life cycle Assessment (Wenzel 1997).The focus of this methodological development is emerging from the more mechanical engineering traditions and is based on the thoroughly study of a reference products. All product qualities and components are parted in individual aspects and being evaluated. The results are then used as bases for improvements in new design (or construction).

UNEP -A promising approach

A 7- step approach was developed by Delft technological Univertisty, Han Brezet and Carolien von Hemel as drivers, and published in 1997.

Step 1 and 2 are the initial steps creating the setting and plan for a pilot-study and deciding the product for redesign and improvement. Step 3 is including the environmental analysis of the product, done through need-analysis (check-lists), MET-matrix (Material, Energy and Emissions through the product life cycle). The results from these analyses create a fundament for finding a eco-design improvement strategy.

Eco design strategy-wheel
The strategy wheel is a spider web diagram consisting of strategies connected to the different 7 main phases in a product life cycle and a @-strategy (*Figure 36*). The ecological impact analyses in the beginning of step 3, is then placed as relative numbers in the spider web. Next, the potential for improvement by the different strategies is marked in the same spider web.

In Step 4 follows idea generation, step 5 introduces detailing and production preparation. Then step 6 prepares launching and step 7 shall be evaluation of the product and planning for a ecodesign program in the company. This methodology is a framework which should be combined with traditional design methodology. It has been introduced to the students in ecodesign courses, and functions in addition to the traditional design considerations, such as aesthetics, ergonomics, function analyses etc.

Alumni at the department of product design engineering, Tor Inge Garvik, spent a semester with employers in UNEP, testing the methodology in Guatemala. The methodology was in this project translated to Spanish and adjusted to local conditions.

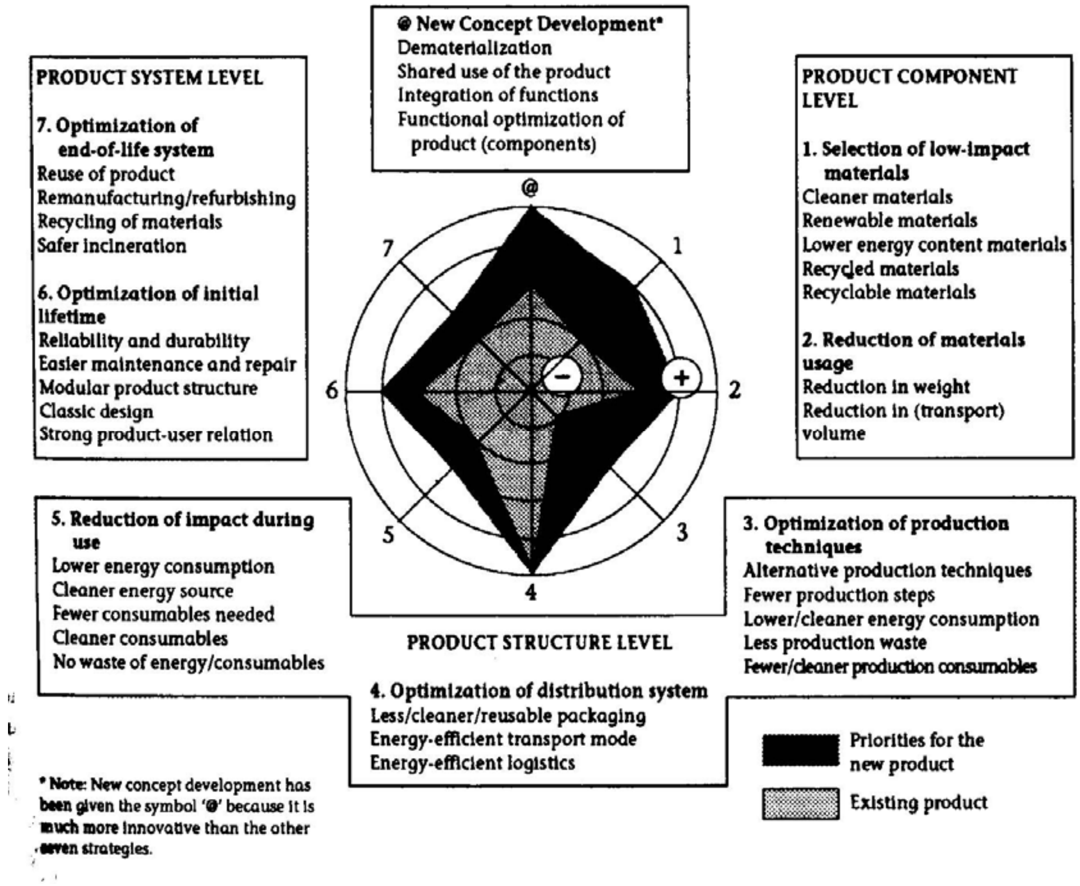

Figure 36 The ecodesign strategy wheel (van Hemel 1994, Brezet, Van Hemel 1997).

@- strategy is representing the strategy of a new product concept. There is, however, a lack of methods in the UNEP-approach guiding the designer from this chosen strategy into new concept ideas. The traditional innovative techniques are available, but the sustainable principles, guidelines and criteria must in some perspectives be introduced also in this work.

Many similar spider-web diagrams have been produced on this same issue. Ursula Tischner is presenting a diagram in her book *How to do ecodesign?*(2001), and the Norwegian initiative by GRIP (Dahl 2004) is presenting their spider-web diagram as well, followed by a check-list.

Hemel is focusing on the eco-strategies in connection with the different stages in the product life cycle, before the idea generation is proceeded, whereas Tischner is introducing general criteria for evaluation of early concepts, considering resource efficiency (material and energy), longevity, avoidance of harmful substances, recyclability, cost efficiency, safety, sustainable use of renewables and fulfilment of needs (Figure 37). The evaluation is done by comparing the existing solution with new detailed concepts.

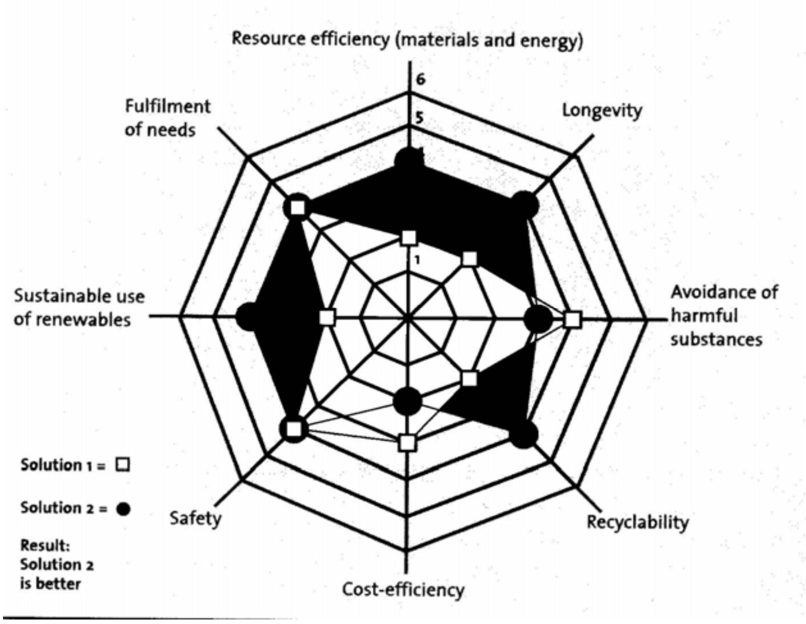

Figure 37 The spider web by Ursula Tischner is focusing on environmental and design evaluation of a new concept compared to the old one (2000).

Claude Fussler and Peter James presented in their book *Driving Eco Innovation* (1996) a spider web diagram (*Figure 38*), placed on different detailing levels of the environmental and business related challenges. They are relating the results to the factor x concept. This spider web is focusing on consequences including strategies: service extension (use intensity), revalorization (and reuse), energy (intensity), mass (intensity), natural material (resources conservation), environmental and health (potential risk reduction)

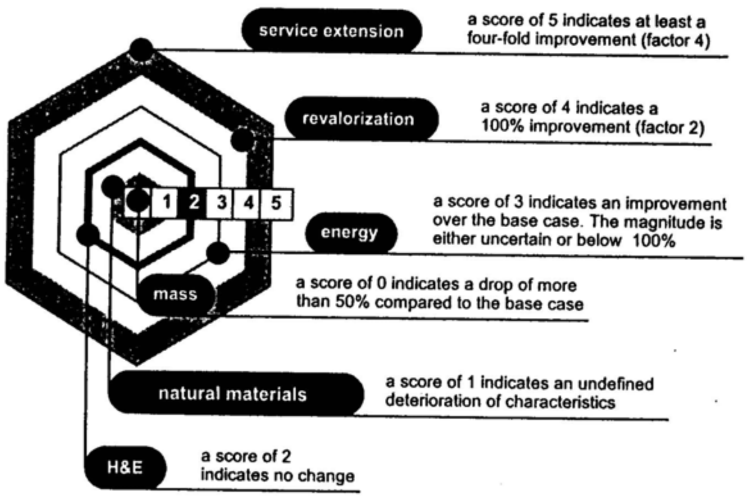

Figure 38 The eco-compass by Fussler and James (1996).

● FIGURE 22.10
Fifth innovative move – look for the eco-efficiency linkages

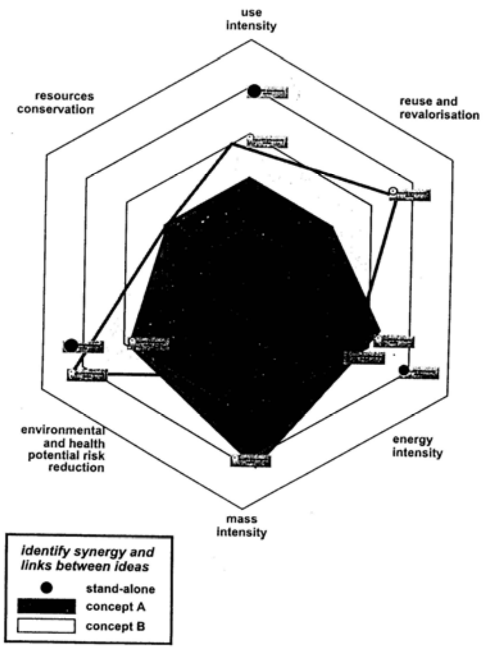

Figure 39 Fussler and James' evaluation of different concept potentials on an early stage in the design process (1996).

Except from the methodology presented by Fussler and James, these methodologies are suitable for smaller changes and improvement of existing products. These approaches might, nevertheless, challenge the existing business strategies and existing products in a company. The Eco-design strategies and decisions are demanding a new set of perspectives and thinking even if it only concerns smaller detailing.

3.6. Summarising and defining the area of research

The existing design methodology is lacking the steps between the incremental changes of a reference product to the design of the "big picture" often neither bounded to local sites nor people's cultural preferences or sustainable evaluation in a holistic long term perspective.
The role of the designer and the placement of the design function in a company is also of importance, in order to reach above changes within the existing framework from a product perspective. A design methodology involving other activities in a company might be useful in order to interfere with the strategic decisions in a company or organisation.

This chapter has presented several types of approaches towards eco-design. Some methodologies are emerging from the more incremental improvements through past pilot-projects (UNEP, Brezet, Hemel 1997), others are aiming for the long perspective thinking through scenario techniques (Weaver et. al 2000) and eco-innovation (Fussler, James 1996)(chapter 2). There are also several practitioners in the field of design and research, who have developed their own, more practical oriented eco-design methodologies. In Norway a national eco-design project was executed by the governmental financed institution GRIP, which resulted in an eco-design manual and eco-design pilot projects, written in Norwegian (GRIP 2003). A Nordic co-operation was completed two years ago with a handbook in environment friendly design, translated to all the Nordic languages (Norrblom et.al 2000). Examples of Norwegian companies, which have made their own eco design manual is Håg ASA (producer of office chairs) and Tomra Systems (producer of reverserd vending machines and recycling systems). International companies that can be mentioned are IKEA (furniture, Sweden), Philips (el-products, The Netherlands), Electrolux (el-products, Sweden) and Herman Miller (office chairs, USA). Many other initiatives could be mentioned, the literature with pilot examples is growing rapidly.

3.6.1 Factor 10 ”per capita”

Factor 10 is through the factor 10 club report (1995), defined as a quantitative reduction in energy, material and emissions per capita in the Western World. This introduces a crucial need for a transdiciplinary approach, where human life style is seen in connection with the social common goods (public transport, waste treatment, energy sources and energy carriers for housing, food production and political incentives) economy and products available, desired and needed. Further, the organising of the private and student/professional life is often dependent on place of housing and eg.social services (such as child care), which are conducting many of our daily moves.
The cultural and social patterns are also important issues, considering the growing amount of single person households. For example, development strategies involving “share-concepts” can therefore represent both economic and practical interests especially for this group of individuals, next to the ecological. However, a user perspective is necessary in order to meet the specific needs and to understand what solutions are appropriate for the specific social group and the individual.

When focusing on single products, systems, and businesses in consideration of Factor 10; the user’s behaviour and life style must also be included in order to be able to evaluate the “factor- effect” (Illustration 11).

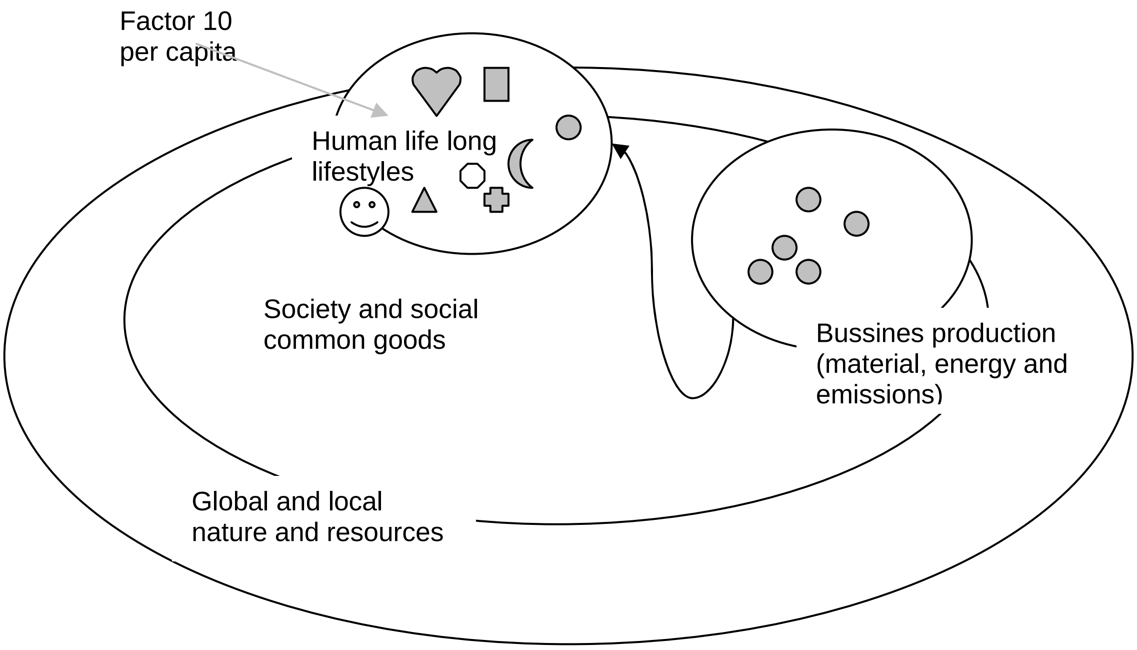

Illustration 11 The factor 10 is related to Western consumption patterns and should be seen as a weighting of environmental impact pr. capita.

3.6.2 The Factor 10 concept in practice

The pilot study study which is described in chapter 5 is focusing on the system co-operation between companies, in order to achieve radical changes in reduction of material and energy consumption. There seem, however, to be a need for a methodology, which is guiding the co-operation in the same direction and which defines the active role of each company.

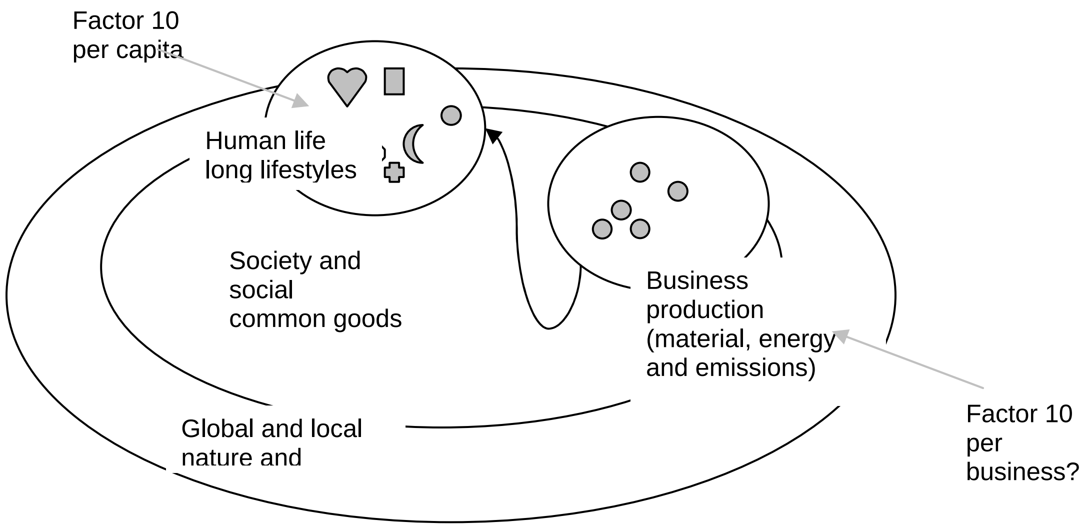

Illustration 12 The businesses should relate their products to the use and consumption patterns it as a part of in the market, in order to evaluate their contribution to a total decrease in material and energy use.

It is hard to see how a business alone can be a "Factor 10" business without relating the products of production to the customer, seen in connection with its final use, the surrounding system and other products, not to mention the needs and activity it is answering and supporting (Illustration 12).

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4.0 Research approach and methods

This chapter will describe the scientific approach for the thesis, and show how new theoretical and practical knowledge by the help of scientific procedures can be created within the concept of design for sustainability.
Since industrial design, which is the starting point of this research, is a young field of profession and even younger in the light of scientific research, it seems important to be aware of the chosen working processes of research and how these processes reach results that are of interest and support to the field.

Like a traveller, the research within the design process will be a journey through a landscape that is not traveled in the same way before (expression taken from Kvale 1997). Other “travellers” will be interviewed about their traveling on previous journeys, how they set their goals, what inspired them and how they felt about the results. All this together will provide pictures for new maps, inviting for future excursions.

4.1 Research areas

4.1.1 Design for sustainability across the three dimensions; product, system and global connection

As described in chapter 2 and 3, the dimensions of a methodology may include global connections, give a framework to the system development and manifest values in the product solutions. The following text is summarising some of the important issues for the research related to each of the three defined dimensions or levels.

Global connection: Factor 20 per capita, involving lifestyles through lifetime living

The factor 10 concept define their reduction of material and energy consumption, and emission outlets pr.capita (STD program in the Netherlands 1998). By keeping this definition, the total environmental constraints are bounded to the human individuals, and show a clearer picture which reveal the differences ofonsumption in different parts of the world. When the reduction of energy- and material consumption is compared with economic units and the increase of the BNP of a nation, this will not give an indication of the situation *pr. capita* in a global perspective, concerning total environmental impact.

Scenario techniques may show the possible directions of future development in a more human-scaled profile, where a people-centred focus with evaluation of life styles and answers to fundamental needs, clearer indicates the real situation. The scenarios must, however, include the prognoses of population growth and access to resources, to picture the consequences in a long time perspective.
The global connection to design for sustainability is so far given through the Factor 10 concept, future scenario building and discussion of ethical and social values and priorities in production and consumption.

System level: When serving the user is a part of the product

Reducing the material and energy consumption by a factor of 10-20 in single products might not be seen as possible in every case. By looking at the products in a wider perspective (chapter 1, *Figure 7*, step 3), including users and user situations, before and after purchase, might create more awareness to desires and needs connected with the meeting between end-user and product. Then by moving to an abstract level, to find the main function of the product and see it in connection with the need and the desire of the customer, some physical products can possibly be replaced or combined with service systems in new solutions (e.g. leasing vs. buying). In the perspective of a lifestyle, the systems must be placed in the connections with different living situations and support the factor 10 thinking but with the focus of enriching daily experiences of quality of life.

For a company, the change on system level is of strategic character and may involve strategies for product extension, service extension and system innovation. Conceptual and system design methods can be useful in the development in this dimension, like Design Oriented Scenarios (chapter. 3.4.3), Use-case study (chapter 3.4.2) and "Thinking–out-of-the box" methods (chapter 2.7.1)

The pilot study presented in chapter 5 is revealing the difficulty to focus on the user experience and human needs in co-operations consisting of companies serving other businesses and in a rather technological perspective.

Product level: Human values expressed in products

Branding and creation of the meta product (Linn 1985) are in traditional industrial design, very important aspects of the product in meeting the market and the end consumer (Vavik, Aubry 1992). The brand building can be rooted in trends in specific market segments (Framnes, Blom, Thjømøe 1990), and/or the philosophy of the manufacturing company based on more timeless values.
There are also different examples of products being developed on the basis of a political or religious belief. These products are often recognised through specific aesthetic characteristics, often in connection with specially developed production processes, in e.g. the Shaker traditions (Sprigg, Larkin 1987) and Scandinavian Design (Halên 1996)(Wildhagen 1988).

The search for guidelines, creating long lasting classical design, has been done from many different points of view and motivations (Pye 1978). The driving forces in market, the universal fundamental needs of human beings (Max-Neff 1992) and a product's certain appearance, interact in complex patterns and will decide the lifetime of a product concept selling on market. This will also be of major importance creating ecological suited product concepts obtaining high market shares and reaching intended lifetime and lifecycle sequences. The intention of the company and designer behind a product design and production can be reflected as a "message" in the product, which can create immaterial bounding to the product by the end user. The understanding of the product message can affect the behaviour of the customer and influences therefore also the sequence and time length of the product's user phase. (Papanek 1995)(Walker 1999). The final design of the product will manifest the choices of product values through such as the shaping of product semantics, choices of materials and preparation, and creation of the product life cycle. Visions and stories can be inspiration to the intention behind the design of the total solution.

4.2 The philosophy of science

4.2.1 Phenomenology and its relation to other traditions in science

Phenomenology is a philosophy of science, which emerged from the social sciences in search for a world view that included the human activity and processes. Edmund Husserl was one of the first philosophers dealing academically with phenomenology by investigating "things as they are" or the essence of things (Mo 2003). Husserl came from the positivistic tradition. Positivism is a more pragmatic approach and is in larger extend been used in the natural scientific traditions. It was originally introduced in early social studies by August Comte (1798-1857), who believed that the social world could be described by similar laws as those found in the natural science. Positivism defines only phenomena, which can be observed with the senses as researchable, however, the observation is only science, when it can be directed or interpreted by a theory (Mo 2003). In this perspective normative assertions or value statements can not be observed and included in science. The most famous group discussing and developing Positivism was the Vienna Circle. The members where striving for a general research approach including also the physiological and biological science.

However, the criticism to the positivism and one of the reasons for the collapse of this research perspective was the lack of holistic approach in answering more complex questions concerning both human life quality and natural phenomena (Mo 2003). Realism was a reaction to Positivism, and the ideas of truth and reality were seen as more central than the framework built on theory. The theory for realists describes real world and the research scope was to reach something real.

4.2.2 The epistemology and science of phenomenology

Phenomenology is based on the interaction between the outer and the inner world of the human being. The reality and the I, are standing in a dialectic relationship. Dialectic, comes from "*dialektos*" in Greek, where "*dia"* means "*through"* and "*lektos* " means "*speech"*.
Phenomenology assumes constant interactions between the body, the human consciousness and the world. In contradiction to this stands e.g. Realism, which says that what is out there is independent from the human beings and their experiences. It just needs to be discovered (tested and observed) and to be described in words and numbers.

In the phenomenological research the researcher is trying to make an understanding of an existing understanding. In this, there is an exploring attitude, which shall lead to the creation of new and different worldviews. The research goal is to reach a new interpretation of known phenomena. The process is dependent on an exchange between involvement and distance by the researcher to hinder the researcher to become too integrated in the situation and unable him or her to make a holistic interpretation.

Molander (1996) points to the dialogue as a basic model for the generation of knowledge. The dynamics of the knowledge is in many aspects identical with the dynamic of the dialogue. Texts, arts, and other activities based on a meaning, can also take part in the dialogue. The dialogue is in itself an art, containing formed and spoken sentences, body language, and thoughts, all connected to a total activity.

The dialogues of Socrates, written down by Plato, were mainly discussing the themes of beauty, justice and knowledge. They were pointing to how we should live, and how the world is.
The dialogues would often end with no answers to the questions, which were asked. This explains how a dialogue is a never ending project, which again indicates what type of knowledge that is generated through this dialogue. Molander points to two different types of knowledge. First the type, which never can be made complete, that means that the knowledge is concerning problems which we should have and be a part of. Secondly, the knowledge, presented in the form of a text or dialogue, should be understood as an invitation to anyone to be part of a real (socratic) dialogue. The critical type of question in this dialogue is supposed to release knowledge from dogmatic beliefs.
This process demands a consciousness concerning own lack of knowledge to start the process of questioning.

The dialogue is depending on the participants and their skills in questioning and answering. The knowledge will never appear as "positive theory" which can be tested "objectively". The knowledge is connected with the participants, and one should be a participant in the dialogue to take part in the knowledge (Molander 1996).

4.2.3 The epistemology and science of hermeneutics

In hermeneutics and phenomenology, reality depends on worldview of the living being. In the hermeneutics though, the reality is in addition something more than this and consist of all the different worldviews together (Christensen 1997).
The two different directions are expressed very much the same or very different, depending on the different philosophers and researchers.
Hermeneutics is said originally to be a way to analyse texts and literature, but all written words also point back to human understanding and the situation of being a human. This gives hermeneutics a close relationship to phenomenology, which starts with the philosophy of ontology and how the world may be understood through the human subjective eyes.
It is for both directions proclaimed that science in any case will be a subjective matter.
This is explained for instance through the hermeneutic spiral. There is an interaction between subject (researcher) and the object (matter or phenomena being studied). The subject will gain new insight in the process of interaction with the object. This will affect the next interaction between the subject and the object (or even a new object).

According to the consequence of this constant learning or evolvement, the testing or observation in a scientific research will depend on the subject, but will also depend on the object, if the object is a living individual (animal or human).
If an interview with a person is done twice, the interview object will have changed more or less during the process itself, and can never be exactly the same person as he or she was in the beginning of the first interview.

As another example, Gadamer (1999) is discussing the dilemma between life-philosophy and science, and how Wilhelm Dilthey is concerned with the question of *historical* consciousness in the work of historians. Dilthey sees the possibility of achieving objective science in this field, by working with *the structure* of larger historical units.
"…a word can be understood only in the terms of the whole sentence, and the sentence fully understood only within the context of the whole text, indeed of the whole literature." (Gadamer 1999, p.231).
This bounds the results to the time and place. The knowledge is relevant within a certain context, but at the same time to a more holistic perspective. How the researcher can see the understanding between the different layers of the structure, resulting in objective science, is then according to Dilthey, based on the belief in homogeneity of human nature and psychology of understanding.

The way of working with structures rather than smaller fractions, seems to avoid the simplification of a research object but is bringing other questions and problems to the front, concerning for instance personal dependency of the results (which was exactly what Dilthey was trying to avoid).

How a researcher decides how to approach a research problem, is depending on the personal position he or she has taken concerning ways of creating new knowledge (epistemology), and how the traditions are in his or her certain field of research.The results are further dependent on the chosen methods used to explore the problem definition or research questions.

What reflections can this give us? In phenomenology and hermeneutics there is seldom a goal of revealing certainties, because what is certain will change while the researcher will try to reveal it or the certainty will not even exist. There will instead be worldviews and experiences "caught" by the researcher at different moments, which can give a knowledge increasing the understanding of the world, and the living.

Gadamer proclaims that hermeneutics is not a scientific method in it self, but a philosophy (Mo 2000). It is then interesting to look at the expectations of the scientific result, in the light of the consequence of this philosophy. The methods used, inspired from this philosophy to achieve new data, might not be as different as from other qualitative or quantitative methods, but reproduction of any of this type of scientific results will seem impossible. All new knowledge will be there not as a final answer to a question, but as one of many possible answers.

4.3 The research design

4.3.1 Flexible design research

Colin Robson (2002) distinguishes between two different research designs. A Flexible research design is characterised by the modification of the research questions as the data collection and analysis proceeds. In fixed designed research it is necessary to have the questions and priorities early in the process, whereas the pilot phase is only for fine-tuning the questions.

The fixed design research can have an experimental strategy, where effects are measured after manipulating one or more variables to a situation. The details of the research design are then fully pre-specified before the main data collection begins. The non-experimental strategy in fixed design is not manipulating the object of study. There is in both strategies typical a pilot phase where the changes are made if necessary before the pre specification is made.

The traditional strategies within flexible research are the case study and the ethnographic study. The case study is development of intensive knowledge about one case or a small number of related cases.

The details of the research design appear during the data collection and analyses. The collection of information via different data collection techniques is typical (e.g. Interview, observation, documentary analyses). The ethnographic study is characterised by trying to answer questions concerning specific groups of people or aspects of life of a particular group.

The research is built on different type of enquiry processes depending on its purpose. Robson is presenting the four classifications: the Exploratory (investigating approach), the descriptive (portraying a profile etc.), the Explanatory (often explaining through casual relationship) and the Emancipatory (be a part of the research and manipulate social action).

All these classifications can be presented in flexible designed research. The descriptive and Explanatory approach is also to be found in the fixed design.

Quantitative research methods and qualitative research methods
The fixed design approach is in general most appropriate to studies of a quanitative character. Surveys, instrumental numeric measurement and other forms of quantitative data collection are depending on a pre-specification of purpose and procedure in order to be found from relevant sources and of high quality. These methods require a high degree of participation by the researcher, defining the framework of the study. The flexible design is dominated by qualitative research methods. These methods include the research objects to a higher degree and are represented by case studies, action research, observation, and deep-interviews. The preparation of framework and premises of these studies is also requested, however, the results may influence the process during the execution.

This thesis is based on a flexible design, where the research questions are slowly evolving and finally fine-tuned after a pilot study. Qualitative research methods are used for the empirical data collection.

4.3.2 The multiple methods

Triangulation including both quantitative and qualitative data collection is supporting validity and can introduce different perspectives to the research. Comparing specific knowledge with general numbers can provide important perspectives to the understanding and analyses of the material (e.g. micro and macro comparisons). This work is basically combining different qualitative methods (pilot-study, case-study, deep- interviews) There are some numerical data in the theory, this is not explored further in the research as such.

4.4 Research questions

the need for a holistic and concrete approach

A1 To create significant changes in the direction of a society with sustainable patterns, human behaviour and culture must be part of the guidelines for new design and system thinking. Designing the premises for a user-activity is as important as designing the product and system solution itself.

By focusing on the user activity and the total user experience, the design process will call for deliveries which are represented by various companies in an integrated total solution. Factor 10 design solutions require developer, company and organization co-operation to arrive at solutions on this system level that lead to intensive reduction of material and energy consumption. This invites designers representing companies and organizations to work in larger collaborative ventures to achieve holistic results. In this perspective the design process is an important part of the strategic thinking in the involved corporations.

Research questions
Q1 How can product- and system concepts be designed to promote a factor 10 development?

> **Q1a** Can connected functions and experiences serving the end-user be the starting point of co-operation between the main stakeholders, rather than the products themselves?
> **Q1b** How could a new methodology include the long term perspective and the short term steps coordinated in the development of new concepts, and in the setting of a company and/or organisation?

The need for early concept evaluation of sustainability performance

A2 The qualitative characteristics of the solution are also of major importance in reducing toxic emissions, sustainable use of materials and energy and non-material perspectives in design, such as social and ethical values. These issues must be integrated in the early phases of the design process to complement the available quantitative information and analyses. If we are to design sustainable solutions, developers must also include more qualitative prime movers (drivers) from human instincts, motivation, acceptance and needs; along with prime movers from the economic and technological climate embracing the product and system concept building. Ecological problems depend on solutions resulting from a change in human- thinking.

Research questions

Q2How can design concepts be evaluated in the early phases of the design process, concerning their ability of contributing to a future development in a factor 10 direction?

> **Q2a** How are the different principles of sustainability, guidelines and criteria defined for the new concepts?
>
> **Q2b**How will the principles of sustainability, guidelines and criteria enter the design process to promote and evaluate future factor 10 solutions?

4.5 Research aims and objectives

Aims

- To create a methodology for development of holistic sustainable solutions.
  -alter the mindset from product- to human activity thinking, integrating human needs in a long term sustainable perspective
- To develop an integrated tool for designers and the design team, to guide and evaluate their concept development in an early phase of the design process, towards sustainable solutions

Objectives

- Exploring the holistic design thinking and ideas of sustainability through eco-philosophy
- Exploring the existing factor 10 concept and research
- Capturing the pragmatic design approach in practice

4.6. Contribution to the field

This thesis is focusing on the system idea and concept designing and how the issues of sustainability can be introduced on an early stage of this type of design processes.
The thesis is therefore challenging the role of design and designers in companies and organisations by focusing on the early stages of design of product system concepts, designing is becoming a strategic tool for business development and value priorities into the future.

Keywords to the work:

- Cooperation
- Communication
- Vision and strategies towards sustainable solutions

4.7 Target groups for this research

- Companies/organisations with an innovative and responsible nature.

- Development of new business concepts through cooperation between several actors.

- Companies/organisations in change and renewing processes.
- Researchers in cooperation with companies and organizations.
- Initiatives from municipality in co-operation with businesses and others, in design of systems and services of common goods.

4.8 Research structure

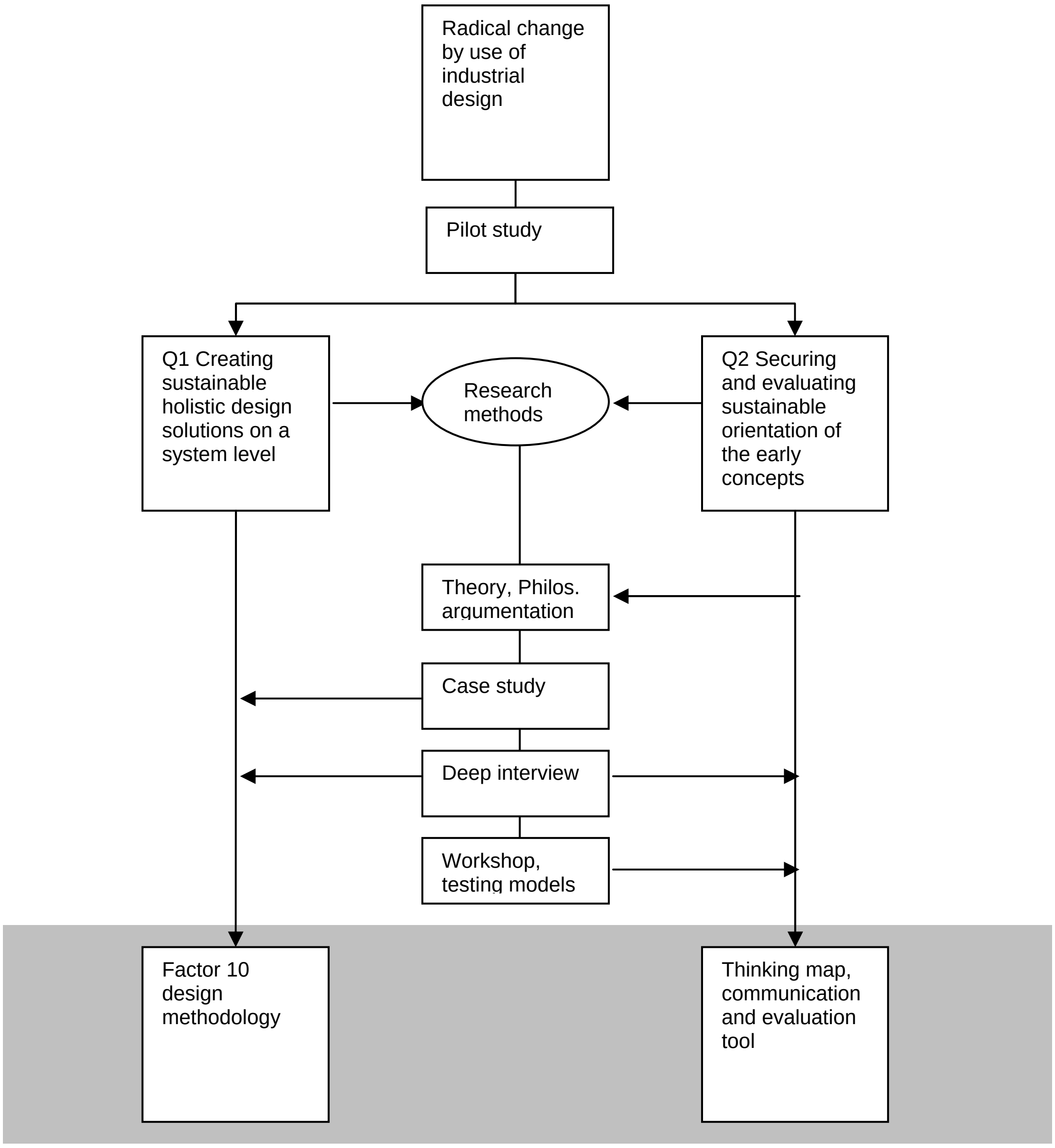


Figure 40 The figure is presenting a schematic structure of the work in terms of the research questions and aims of the thesis.

The thesis is built on a flexible research design approach, where the material is collected align with the development of the research questions. The experiences from the pilot study, clarified some crucial aspects, which influenced the final tuning of the focus for further data collection and empirical studies and analysis (Figure 40).

4.9 Research approach

4.9.1 Data collection

Strategies of data collection
There are different directions of qualitative research and followed data analysis. Miles and Huberman (1994) are presenting a tree (Wolcott 1992), which is explaining the connection between four different main strategies of educational research: Archival strategies (including philosophy), Interview strategies, Nonparticipant observation strategies and Participant observation strategies (field study). This thesis is including research in three of the four strategies. Nonparticipant observation has not been a chosen strategy.

Types of qualitative data
The different qualitative research types which are most relevant for design research, seem to be from the Graphic overview of Tesch (1990) (p.7, Miles and Huberman 1994),

- The characteristics of language, and then as culture, both in a cognitive and interactive sense (related to design through aesthetics, symbolic expression, usability, man-machine interaction, etc)
- The discovery of patterns, and then as discerning of patterns, and identification (categorisation) of elements and exploration of their connections (related to design through development and study of design methodology and process, methods for user analysis, product structure and dimensions, production processes and use materials, etc)
- The comprehension of the meaning of (text)/action, and then as interpretation and discerning of themes (commonalities and uniquenesses), (related to design in the design process, the act of designing, team processes, and understanding user patterns and translate their actions into design criteria, etc)

4.9.2 Research methods used in this project/thesis

According to the theory of qualitative research (Miles and Huberman 1994) this thesis is built on empirical material and data collection as following

Archival strategy:
(Q1) Reality case study: The Lillehammer Olympic Winter Games 1994
This study is done through literature, deep interviews, and authentic material from the design process (design manual and handbook)
The purpose with this study was to discover patterns and experiences, which could be transferred to the factor 10 design methodology, or emphasize the differences.

(Q2) Philosophical logic argumentation: Based on literature study from eco-philosophy and ethics; this method was used to discuss sustainable perspectives, human values and qualitative characteristics of human made systems in the light of product and system design. The purpose was to comprehend these texts and connect them the themes of sustainability. This work, however, is placed in the chapter of theory (chapter 2)

Participant observation strategy: discovering of regularities and discerning patterns-
(Q1) Action research: Pilot study
The pilot study was done in two steps (pre- and main-project) to explore the practical approach within the factor 10 concept. The study involved Norwegian companies and researchers. The pilot study should indicate possible patterns for a new design methodology, but also emphasizing problematic steps. If the pilot-study can be defined as action research might be questionable, however, the process and methodology in the pilot-study was influenced by researchers throughout the project and were at the same time objects for research.
The pilot-study is followed by deep interviews of 4 of the participants in the project.

Interview strategy:
(Q1 and Q2) In depth interviews: revealing further aspects, confirming or questioning results

The interviews where done in the last phase of the doctoral work. The interviews should enlighten the total material from three different main perspectives. The texts from the transcriptions were coded and analysed concerning methodology, human processes and project management.

The purpose of in depth interview may be of different character depending on the type of research. In this project there are three groups of respondents and each group has been chosen according to different aspects of the study.

A. designers who work as both researchers and designers (1,2)
This group did not contain specific ecologically interested designers. The aim with these interviews was to relate the material to other foci in the industrial design field, such as aesthetics and interaction design. It was also of important interest to reveal other possible design methods that are useful to the factor 10 design concept.

B. Participants in Pilot study factor 10: researchers and business executives (1,2,3,4)
This group should increase the knowledge and experiences from the research projects and present perspectives which was not represented in the report or in the view of the participating interviewer.

C. Participants in reality case study, designers/project leader (1,2)
These interviews should bring relevant information about the actual design process from favourable examples from practice, and new specific insight in addition to the existing written material about this project.

A common theme for all the interviews was design methodology for system thinking and how to develop holistic solutions.

The phases in depth interviews

Kvale (1997) is presenting the qualitative in-depth –interview methodology in seven steps of action:

- Define theme and scope – what is the object of interest for the researcher and why
- Plan – who shall be interviewed and how, an interview guide is created
- Interview – how is the setting of the interview, length and methods for recording the material
- Transcribe – process of transforming the audio material into written material
- Analyse – systematizing and interpreting the material related to the defined scope of carrying out the interviews
- Verifying – ensure the validity of the material
- Reporting – communicating the conclusions in an interesting and relevant manner

The ethical and scientific criteria must be present and have to be.

The ethical criteria
The personal relation between respondent, interviewer and theme and scope of the interview must be evaluated before the interview is made. In this research the theme is not of personal character, but personal motivation and involvement is revealed by most of the respondents during the interviews. The interview respondents were given the choice of being anonymous in the final presentation of the results. In this work one of the respondents requested to be anonymous and therefore all the respondents are referred to only by their working title.

The scientific criteria
The quality and scientific value of the conclusions and use of the in-depth-interviews are depending on different criteria. The interview itself is the raw material of the research method. Further analyses and conclusions are depending on the quality of the interview. Kvale (1997) is referring to six criteria for a high quality interview:

- The degree of spontaneity, specific and relevant answers from the respondent.
- The shorter questions and longer answers the better.
- Following up questions from the interviewer, revealing more of the relevant answers.
- Interpretation of the answers as far as possible during the interview.
- As far as possible, verification of the interviewers interpretation of the answers during the interview.

- The interview becomes a self explaining story when it is closed and does not require additional comments or explanations.

Further, a high quality interview also demands a qualified interviewer.

The following section will describe the actual seven steps prosecuted in the deep-interviws for this research.

Define theme and scope – what is the object of interest to the researcher and why
The interviews are entering late in the research process (see process description Appendix, p.xx)
The main themes of the interviews were:

“Reality check” Interviews(A):
Two deep interviews were made to evaluate the climate within other design research areas, in this case, aesthetics and man-machine interaction, to evaluate the tendencies and parallels in comparison with the factor 10 experiments.

The objective of these deep interviews was based on one motive:
- The theory and pilot study should lead to the development of tools, which are realistic to implement in some type of design processes in industry today. The deep interviews should map some of the activities within other types of design activities.

Post pilot-study Interviews(B):
In Autumn 2003 four of the participants in the projects were respondents in deep interviews prepared and done by the PhD candidate. Three of the respondents were participants in the main project. One interview object was from the pre-project and had only initially taken part in the main project, but attended the final seminar summer 2003.

The objective of the deep interviews based on three motives:
- To evaluate and compare the weight of the time spent on different foci in the project vs the outcome and expectations. This is important in the terms of motivation and further development of the methodology considering the selection of goals.
- To develop the characteristics of the methodology to become more clear for future communication and introduction of the new methodology.
- To reveal the main barriers for implementation today and the positive drivers.

The case-study interviews(C):
Two key-actors in the design process of the design programme and manuals for the Olympic Winter Games Lillehammer’94 were interview respondents. The case-study had been chosen because of the system dimension in the design task involving visual profile, services, products, architecture and logistics. The research strategy was to investigate how procedures and mechanisms in this study may be translated to a factor 10 design project.

The objective of the deep interviews based on two main motives:
- To understand how to create a basis for a common vision.
- To reveal the driving forces which mobilise a number of stakeholders in the use of the common vision.

Plan – who shall be interview and how; interview guide is created
The respondents are divided into three groups, which are consciously chosen from staff of the Department of product design engineering, the reality case study of Lillehammer ’94, and participants in the pre-project and main project of the pilot study. The interviews were all planned to be recorded on tape, notes were made during the interviews, but mainly to remind the questions following up the statements from the respondent.

The interview guide
The three groups of respondents were interviewed on the basis of three different interview guides. The overall themes were equal for all the guides, but were enlightened from three different perspectives and required therefore different specific questions. The interviews consist of open and more leading

questions. In some occasions the interviewer explicitly expressed that a certain question was leading the respondent.
The guides in this study were structured by different subjects of discussions with specific introduction questions (Appendix VII). The answers of the respondents indicated the further following up questions. If the respondent did not answer the question as precise as desired, the interviewer asked the question specifying the focus.

Interview – how is the setting of the interview, the length and the methods for recording the material
The Interviews are made mostly at the working site of each respondent, either in their personal office or in a suited room. One respondent came to a location organised by the interviewer. Each interview is between 50- 90 minutes. All interviews are recorded on a tape recorder. To concentrate fully on the interview respondent, the interviewer did not take mentionable notes during the process.

Transcribe – process of transforming the audio material into written material
The tapes where transcribed literally, word by word in word files. This is seen as a more handicraft way of transcription according to Miles and Huberman (1994). There is computer software and recording devices, which are able to digitalise the text and ease the coding and further procedures before analyses. However, this is not the case for interviews done in the Norwegian language (ref Ingunn Amdal, SINTEF)

Nodding and positive comments like "hmmm" from the interviewer is not included if it is not seen as important to connect the text. The interviews are transcribed as accurate as possible from the tapes, in Norwegian, but is afterwards partly translated into written English language. (Appendix part VIII).

Coding system

The coding is related to the research question in terms of what type of delivery which is expected.

The *macro clusters* are the main themes in the coding which give structure to the interview content. For the discussed interviews the macro-clusters where made in order to find a common structure for all the interviews in relation to the common theme, design methodology and surrounding conditions.

Macro-clusters:
Framework: contexts and conditions for good projects.
Project management: how the projects are organised and driven.
Process: what seems to be of importance for participants, drivers and motivation.
Methodology: steps on the way to a result.

Coding of interviews

The results from the interviews are following in chapter 8.

Macro-clusters	Micro-clusters:	Source A (design/research)	Source B (pilot: factor 10)	Source C (case: OL'94)
Framework:	Networking -strategy in business concepts	A1, A2	B1, B2, B3, B4	C1, C2
	Drivers/starting point/values Common interest	A1, A2	B1, B2, B3, B4	C1, C2
	Future possibilities, barriers/challenges	A1, A2	B1, B2, B3, B4	C2
Project management	Ownership-steering	A1, A2	(B2), B3, B4	C1, C2
	Role of the designer	A1, A2	B1, (B2)	C1, C2
	Project panning Long term/short t.	A1	B1, B2, B3, B4	C1, C2

	Design methods/ methodology	A1, A2	B2, B4	C1, C2
	Symbiosis design and research	A1, A2	B2, B3	
Human processes	Communication -strategy in project	A2	B1, B2, B3, B4	C1, C2
	Motivation -ownership, emotional	A2	B1, B2, B3, B4	C1, C2
	Working methods	(A1), (A2)	B1, B2, B3, B4	C1, C2
New Methodology	Scope definition	A1	B1, B2, B3, B4	C1, C2
	Analyses	A1, A2	B1, B2, B4	C1, C2
	Scenario building	A1, A2	B1, B2, B3, B4	(C2)
	Vision	A1, A2	B1, B2, B3, B4	C1, C2
	Strategy -in system/product	A1, A2	B1, B2, B3, B4	C1, C2
	Idea generation Design of concepts	A1, A2	B1, B2, B3, B4	C1, C2
	Evaluation of concepts	A1, A2	B2, (B3), B4	C1, C2
	Further development/ design and detailing	A1, A2	B2,	C1, C2

Table 11 Coding of interviews, content and groups of respondents.

Analyses – systematizing and interpreting the material in connection to the defined scope of carrying out the interviews
The interviews were made including following up questions as far as possible to create clearer statements or deeper explanations of expressions or defuse statements made by the respondents. The material from the interview in group B and C was also seen in connection with written reports and visual results (group B and C).

The analysis is an open discussion in chapter 8. The material is here analysed in the light of the research questions (Table 21).

Verifying – ensure the validity of the material
The interviews are prepared and executed after the actual prescription. The content of the interviews is specific though, both connected to the interview respondent, their personality and the interviewer.

Reporting – communicating the conclusions in an interesting and relevant approach
The results from the interviews are spread to the relevant chapters and subchapters. It is always indicated though, when the material is referring to the interviews. Chapter 8 is the mainly based on results from the interviews, presented in relation to the macro clusters. The translation of the intervies from Noregian to English is a critical step in the process (Appendix IX).

Conclusions

The conclusions are made on behalf of the material explored in this study. The attempt to make generalisations in chapter 10, is also indicating the need of discussion and further studies to support or undo the suggestion of the general framework for Factor 10 designing.

Trustworthiness

Research involving people will always include the problem that identical circumstances never can be re-created. This means that a reproduction of the experience is not possible, even if all sources, interview transcriptions, interview guides, and written material can be reviewed.
Elegance, coherence and consistency are characteristics which are more appropriate to this type of qualitative studies (Robson 2002). The material is presented as transparent as possible in order to expose the pathway of research to the reader of the thesis. This leaves a possibility for the reader to evaluate the conclusions based on the methods and results.

The four different research methods introduce different challenges concerning their trustworthiness. The action research is a research method where the researcher is in front of the process and facilitates the activity of the other participants. In this thesis, the research data is complemented by in-depth interviews in order to capture more perspectives of the actual processes than the visual and written material expose (triangulation).
The logic argumentation is directed and reflected under certain normative conditions. On the other hand, the literature can be read and interpreted by others and therefore opens for argumentations also in other directions.
The real case study consisting of material available for others and can be re-studied.
The interviews are not re-producible, but are executed by instructions of in-depth interviews. The transcriptions are available in Norwegian. However, the analyses consist of translated statements and English coding (Appendix Part III, IV).

4.10 Contribution from scientific research to design practice

4.10.1 Contribution of thematic knowledge

In the case of material use, emission outlets from the production processes, transportation and waste treatment, The ecological impact from the product will under certain circumstances be measurable. This is done today by the methods of life cycle analysis and other methods (see ch. 3.1, table Table 10). The long term impacts, ecological impact of change in behaviour, and mental attitude of the user of the product, are much harder to study, if not impossible in many situations. Here the professional experiences and abilities of the designer plays important role in the situated action. The holistic product will not appear automatically through scientific valid fragments of knowledge.

Results from the natural sciences, social sciences and the humanities, can all be interesting and of major importance concerning single elements in the product or choices of design strategy in a design process (Figure 41). The design process itself is not a scientific action considering the demand towards the results of being reproducible. Two different designers will never achieve exactly the same product design, although they have the same information during the process, and they follow the same design methods (Stolterman 1994). This is neither seen as desirable.

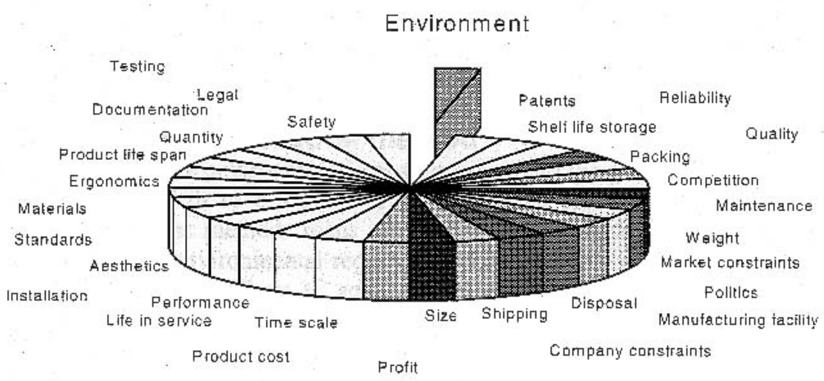


Figure 41 "Representation of all the demands that must be addressed in product development (Luttropp 1999)" (in Lagerstedt 2000). Specific information from a numerous of disciplines and issues can be useful to the design process and final product.

4.10.2 Research goals within industrial design

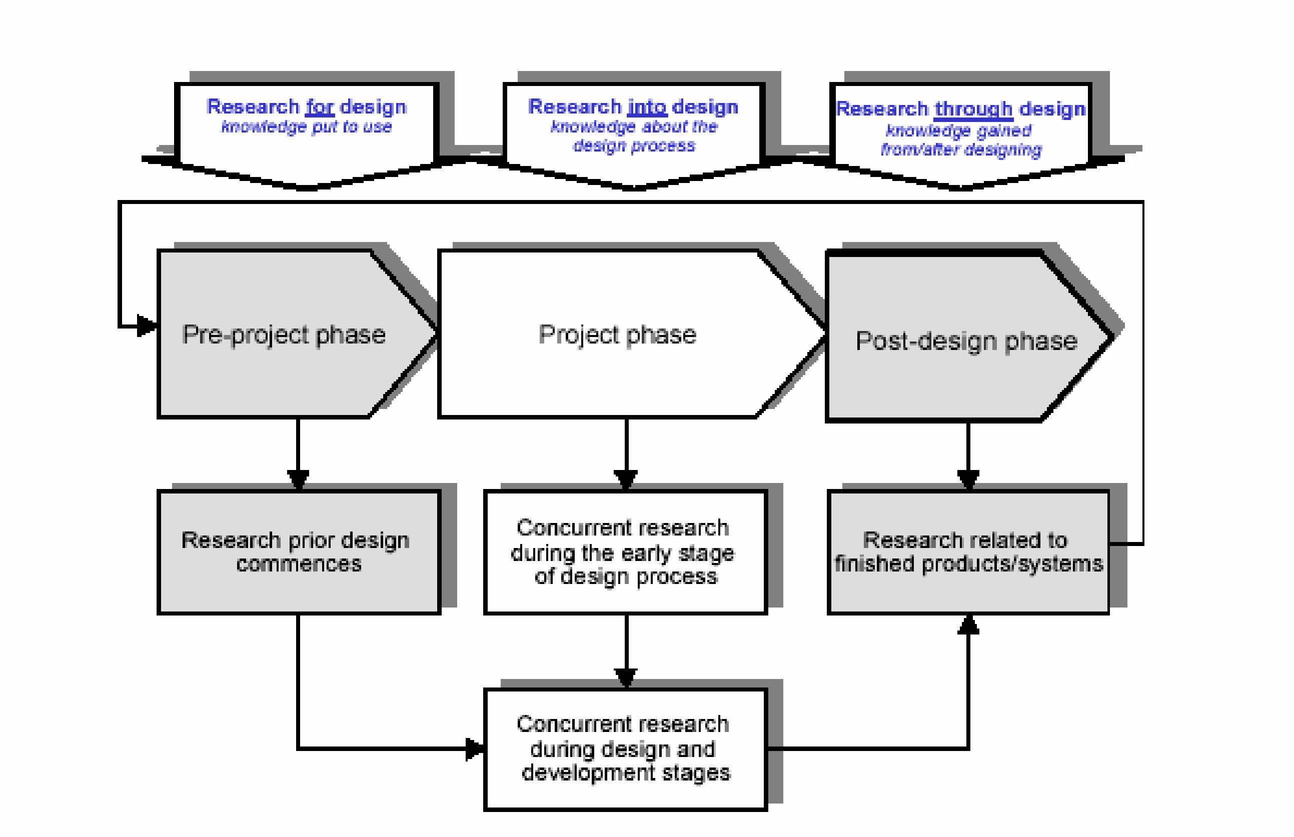
Development of new knowledge within other fields is not a research goal within industrial design research, but *the use* of this knowledge within design can be a goal of research.
In the case of "ecological industrial design" knowledge of environmental challenges is involved, as well as ways of thinking about ecological issues and the connection between human behaviour patterns (psychology, sociology anthropology, etc) and ecological impact.

Sherwin (2001) has used in his doctoral thesis the two frameworks which places the research activity in connection to the designing:

From Cross(2000) research can be divided into three areas:

- Design epistemology: Study of design knowledge (people)
- Design praxiology: Study of the practices and processes of design (processes)
- Design phenomenology: Study of the form and configuration of artifacts (products)

Sherwin also points to others have seen the research more closely related to the specific act of designing, in a schematic manner:



Model 4 Chris Sherwin (2001) has presented in his thesis the design research and its relation to project phases through this model (Popvic 2000, Frayling 1993/94, Woolley 1998 added).

From the design engineering point of view Lucienne Blessing (1997) sees three important contributions from design research to the field of practice;

1) to create supportive knowledge to the design process , such as guidelines and criteria, to create design methodology,
2) to achieve certain types of products and finally,
3) to create evaluation methods to evaluate the results from the experienced methodology.

The research questions in this work are in some extent embracing all these three issues.

4.11 Researching vs. designing

4.11.1 The practical and the theoretical knowledge

The ability to evaluate and make decisions based on experience in combination with for example mathematical accounting, are two facets of the same procedure. Molander(1996) is using examples from forestry where the final judgments are taken on behalf of the totality, putting all the fragments of information together and evaluating the steps of action regard to the future sustainability for the forest and the business.

Molander's (1996) second example is taken from metrology. Here the metrologist has different types of measurements from technical equipment, which are developed to measure different fragments of the activity in the atmosphere. The metrologist then has to evaluate the different results, and by experience and accounting, she gathers the information to a more holistic picture of the weather.
The intuitive knowledge, based on experience and understanding, will vary and therefore the consequence of this working method is different weather forecasts, depending on the meteorologists, who are analysing the measurable data.The practical knowledge may be normative, and is based on experience of what has been successful before and what therefore probably will be successful again.

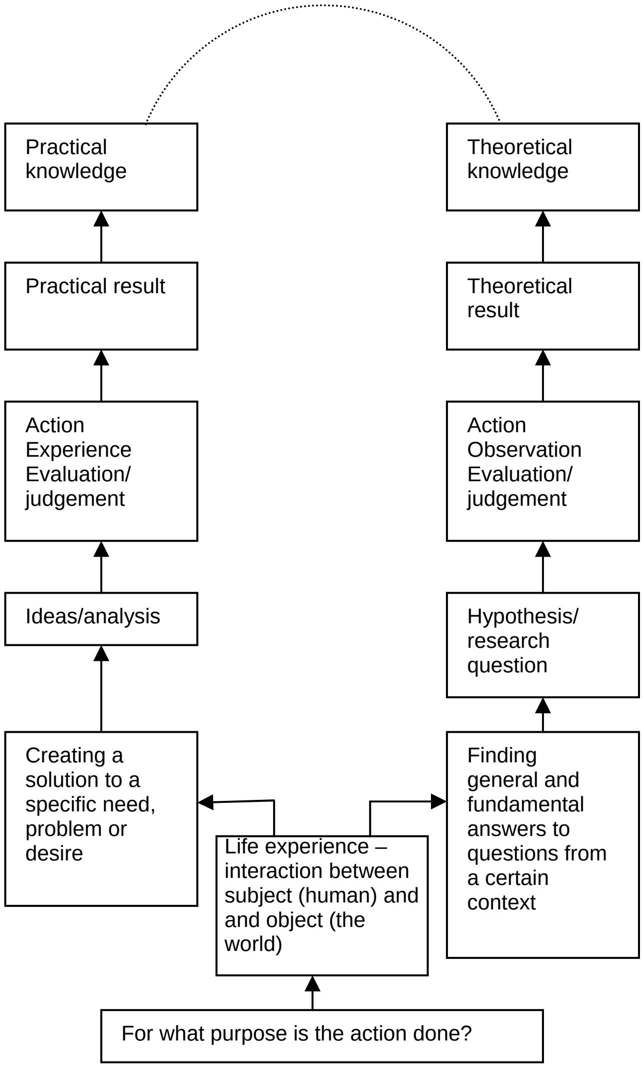


Figure 42 Practical vs. theoretical knowledge. Referring to Molander (1996) the development of theoretical and practical knowledge have the same source in human interaction with the world.

The theoretical knowledge is usually descriptive and describes an observed situation, without predicting future possible situations.These two types of knowledge are created in different ways, where the practical knowledge is definitive and tangible, while the theoretical is constantly changeable and uncertain depending on its interpretation and expression through language and mathematics. In practice and research there is also an iterative process between the practical and theoretical knowledge.

Molander promotes a pragmatic point of view. He claims that all knowledge has a foundation in actions. This is what he calls “the living knowledge”. It may be difficult to understand what Molander really includes in his definition of actions, but it can be interpreted in the way that every abstraction or thought has root in a human’s experiences with, and in the world(Figure 42).

Ulf Linde (in Molander 1996) is defining knowledge as a type of attention to the world and its phenomena. Attention seems for the author as a combination of the moment of experience and the following reflection concerning the experience.Then an experience without reflection will not lead to knowledge. The scientific knowledge after the definition of being reproducible will be experiences done by many different researchers ending up with the same reflections. How must then the experience be, to lead to the same reflections by a certain amount of researchers, or people involved in the research? Perhaps, if there are *fundamental* experiences of the human being, these may be a source for scientific knowledge, which is deeper than the knowledge achieved by taught methods and rules for how to pay attention to *fragments* in a holistic experience.

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5.0 Pilot study: Factor 10[5] drinking systems in Norway

This is the story of a few inspired people who have used about four years to discuss, test and explore the factor 10 concept. This initiative has involved companies, researchers, undergraduate students, graduate students, practitioners and a PhD student. Researcher and professor Ole Jørgen Hanssen has invited numerous participants at different sgaes in the long process, and the material, discussions and approaches towards results have matured along the journey. This chapter will present some formalities from the project as well as highlights and methodological steps which are of various qualities.The experiences from this work challenge both the analytical and analyzing tools from the environmental studies, as well as the creative and qualitative approaches that are typical from rather conceptual design practice.

As mentioned in the chapter 4; in flexible research projects a *Pilot-study* is often carried out to give a clearer indication of issues concerning the research questions and as support for a fine-tuning of questions. Likewise in this study, the questions have been adjusted towards a more concrete direction after the pilot was closed. This pilot is thus not seen as an ideal project, on the opposite it is an experiment in business co-operation towards environmental awareness and future sustainable development.

5.1 Materials and methodology; data collection

5.1.1 Role of researcher,

The PhD candidate was active in the entire pre-project as researcher and partly as designer. The project planning and procedures were set by the project leader, Ole Jørgen Hanssen, assisted by the candidate, who initially was research assistant at the LCA-laboratory.
The main project was discussed and prepared with the same constellations, however proceeded without the PhD candidate until the last two closing seminars out of eight.

5.1.2 Overview of time schedule and study

The pre-project was initiated in spring 1999 and concluded in spring 2001. The main project started in the fall 2001 and finished summer 2003.

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[5] The factor 10 studies started as a priority within the works at the LCA-laboratory at NTNU in 1998. Inspired by the book "*Factor 4, doubling wealth, halving the resources"* written by Weizâcker et. al, and the STD project in the Netherlands, which focused on factor 20; factor 10 became a research issue within the research programme P2005 in the core area *Eco-efficient products and production* (see Preface).
This thesis was initiated in the same period of time, and the PhD work started in the autumn 1999 when the pre-project *Factor x* was running. The pre-project was followed by a main project, which was supported only partly by P2005. Both projects were lead by senior researcher and prof. II Ole Jørgen Hanssen. The pre-project was fully financed by P2005, the main project was partly financed by P2005 and partly by the Norwegian Research Council through the research program VAREMAT.

5.1.3 Student contribution

During the long time span of the pre- and main-project, 6 master students from Department of product design, 2 students from Department of machine engineering, 1 student from industrial ecology and 2 students from NHL have focused on factor 10 in their projects. The student experiences have given more practical input to the research project and have value for this thesis both in process and results.

5.2 The pilot study: Management, Process and Results

5.2.1 Project planning and management

Project planning and management
The Pilot study has been carried out in two phases. The pre-project was executed from April 1999 to May 2001. This project was used as a starting point for a main project which run from summer 2001 to the end of 2002. The main project included several exclusivly invited businesses in a more direct process, studying drinking systems in Norway, trends and future possibilities.

P2005 consisted of core businesses, where three of these attended in the pre-project (Håg, Polimoon and Tomra) and one of them (Tomra) continued in the main study. Additionally two ”external” companies (Elopak, Tine) and one research institution (NLH) joined the project.

5.2.2 Setting up the teams

	Researchers	Business employees	Repeating business employees
Pre project “Factor X”	NTNU 1 STØ 2 Students: NTNU 6	A: 1 B: 1 C: 1	
Main project “Factor 10 drinking systems in Norway”	NTNU (1) STØ 3 NLH 1 Students: NTNU 1 NLH 1	B: 1 + (1) D: 1 + (1) E: 1 F: (1)	(1)

Table 12 The teams for the pre-project and main-project in the pilot -study

The companies, who attended the pre-pilot was Tomra, Håg and Polimoon. The main project was executed by Tomra, Elopak and Tine (Table 12). Lerum was a company, which initiated a co-operation but withdrew early in the process.

Short description of the attending companies:

Håg ASA
Vision: “The HÅG movement; HÅG’s seating solutions are the result of our belief that people are not designed to sit still, but naturally tend towards movement and variation” (source www.hag.no)
The four guiding principles: dynamic ergonomics, environment, visual design and quality.
Employees: -

Polimoon
Vision: “Polimoon is a leading developer and producer of products and applications manufactured in plastic.” (source: www.polimoon.com)
Employees: More than 2300 employees in ten countries

Tomra

Vision: “The world’s No. 1 provider of solutions that make it attractive for people to return packaging for reuse and recycling” (Source : www.Tomra.no)
Employees: 2000 in total

Elopak

Vision: “Elopak's vision is to become the leading international player in the fresh non-carbonated liquid food packaging market.”
”Elopak's mission is to satisfy market needs for attractive high quality carton and plastic based packaging systems for non-carbonated fresh and long-life liquid food products. This will be achieved by continuous focus on consumer and customer satisfaction, innovation, operational efficiency and human capital development.” (Source: www.Elopak.com)
Employees:-

Tine BA

Vision: "Vi skal være Norges viktigste verdiskaper" (Eng.: We shall be the most important contributer to value building in Norway)
Tine Ba is the largest dairy in Norway. (Source: www.tine.no)
Employees: 4300

The researchers’ origin:

NLH, Agricultural University of Norway

Vision:” NLHs role is to be a vital center for knowledge about agriculture and the use and management of natural resources and the environment. NLH should through its activity ensure the basis of existence of current and future generations.” (source: www.nlh.no)
Employees:-

STØ,Ostfold research Foundation

Vision: ”STØ skal arbeide med anvendt FoU som skal bidra til en bærekraftig utvikling innenfor både privat og offentlig sektor med særlig fokus på verdiskaping og effektiv utnyttelse av tilgjengelige ressurser.” (source: www.STO.no)(eng. transl.: “STØ shall work with practical R &D, which shall contribute to a sustainable development both within private and public sectors with special focus on added value and efficient utilization of available resources.”)
Employees:-

NTNU, Norwegian University of Technology and Science

(Vision) “Objectives: We will be rated among the international academic leaders in our main areas of concentration: teaching and research in technology and the natural sciences. /We will offer a broad range of academic disciplines and have internationally recognized quality standards in all areas of activity./ We will be an innovative university concerning cooperation and interaction across disciplinary boundaries. /We will be a critical and constructive contributor to society, with a reflected, comprehensive approach to the many facets of society's tasks and challenges. /We will actively engage the expertise of women in academic development.” (source: www.ntnu.no)
Employees: ca 5000

5.2.3 The pre-project: Factor x

Process

The project group had regular meetings at different locations. All participants had to prepare different material in between the meetings, however, the researchers where conducting the process.

Literature study

A student collected as a summer job articles and material for the project group into a compendium (Mære 1999).
The pre-project was functioning similar to a study group, where the participants read selected articles and presented the content for the rest of the group in appointed meetings. This practice resulted in both a personal and collective wider understanding of Factor x. The term *Factor x* should indicate the

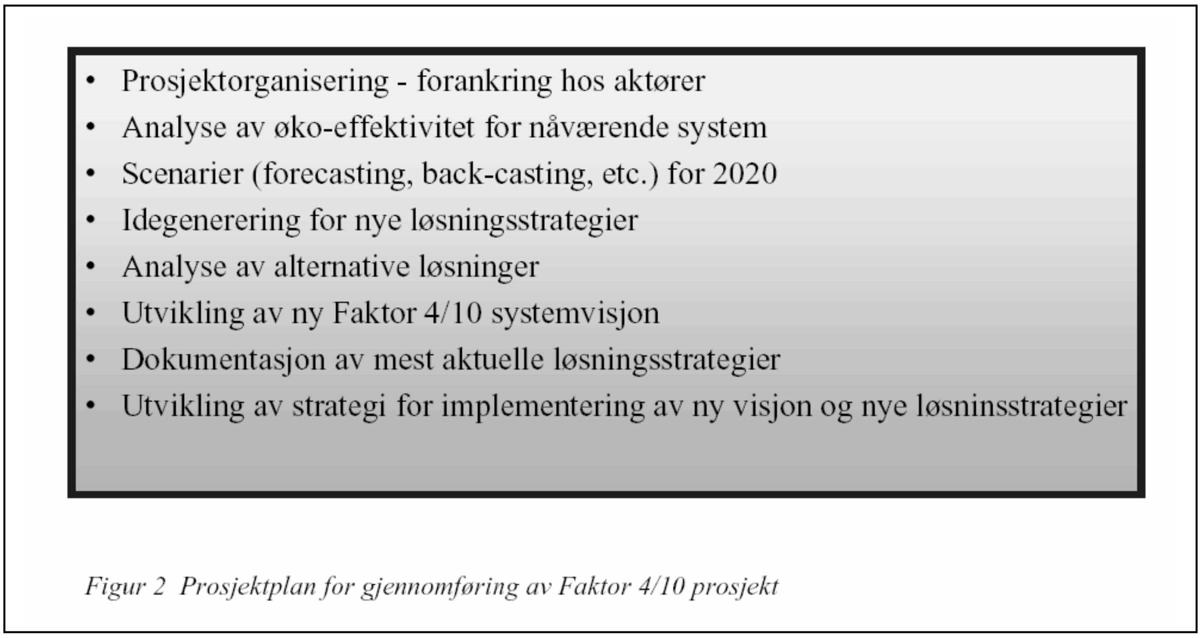
open perspective of the project. The *x* can be replaced by different numbers, depending on the specific situation and view of the theoretical concept (see ch 2.4.1).
Interesting books and conferences were also reported by the different participants on each meeting.

Course development

Three of the project participants (two business representatives and one researcher) developed an eco-design methodology self-study from the existing material in addition to the design oriented material. Two participants (researcher and business representative) and a colleague from industrial ecology, visited Delft University and TNO where they made an interview with Leo Jansen, the project leader of the STD program, a major project on factor 20 in cooperation between Dutch businesses and five ministries (Weaver 2001)(see chap. 3.4 and 3.5.3). This course tended to focus on development of company strategies and thinking in the perspective of a factor 10 development.

The project plan (Figure 43)

- Project organising, placing ownership with stakeholders
- Analyses of eco-efficiency for existing system
- Scenario (forecasting, back-casting, etc.) for 2020
- Generating ides for new solution strategies
- Analysing the different solutions
- Development of new factor 4/10 system vision
- Documenting the most relevant solution strategies
- Development of strategy for implementation of new vision and new solution strategies



- Prosjektorganisering - forankring hos aktører
- Analyse av øko-effektivitet for nåværende system
- Scenarier (forecasting, back-casting, etc.) for 2020
- Idegenerering for nye løsningsstrategier
- Analyse av alternative løsninger
- Utvikling av ny Faktor 4/10 systemvisjon
- Dokumentasjon av mest aktuelle løsningsstrategier
- Utvikling av strategi for implementering av ny visjon og nye løsninsstrategier

Figur 2 Prosjektplan for gjennomføring av Faktor 4/10 prosjekt

Figure 43 Original Project plan (Hanssen et.al 2001).

The goal of the pre-project

As a part of the P2005 Industrial ecology, the core area 1 should include a more radical development perspective of new solutions. There was a high interest in exploring the Factor x concept, and to see if this concept introduced a pathway to a more operational radical design methodology, although this was done on a theoretical level. The pre-project included a data collection and more qualitative analyses, considering drinking systems in Norway. The project was initially meant to address both drinking systems and total office solutions. These areas where related to the activities of the different participating businesses.

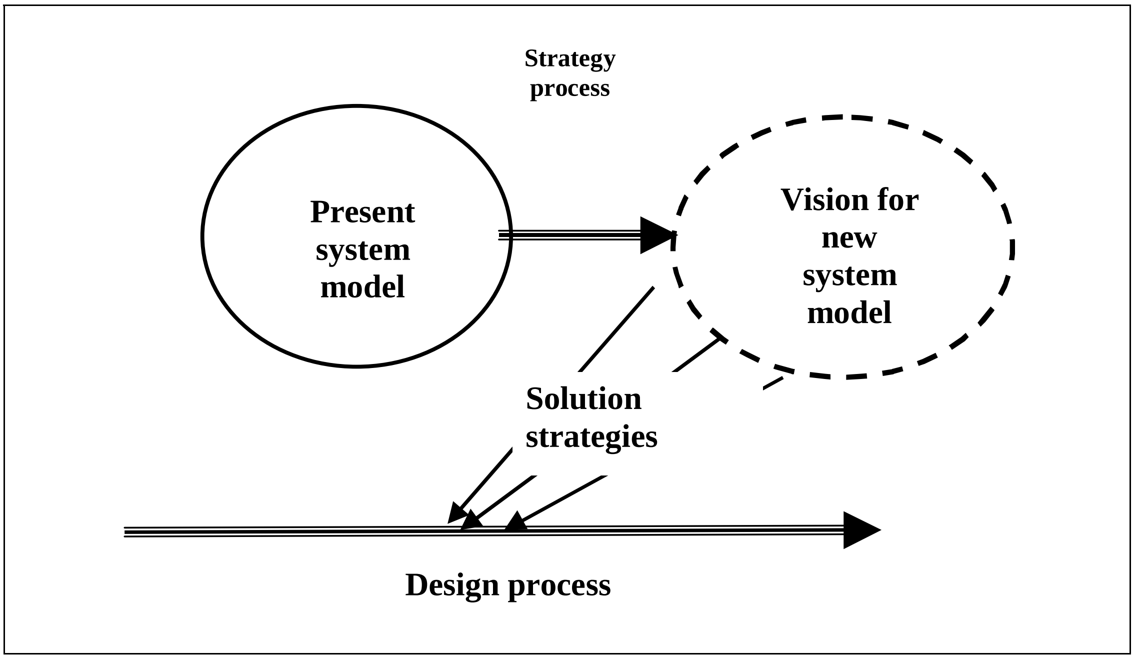


Figure 44 Main principles in the method for Factor 10 Systems Design (from Hanssen et al. 2001).

The project group analysed the existing system in order to create visions for a new system model leading in a factor 4/10 direction (*Figure 44*)(Hanssen et.al 2001).
The project group selected initially two areas for the study, namely drinking systems in Norway and office solutions for the future. These areas were related to the core business of the companies, who where involved. For practical reasons, the group continued later in the project more intensive on the theme of drinking systems in Norway.

Quantitative and qualitative analyses

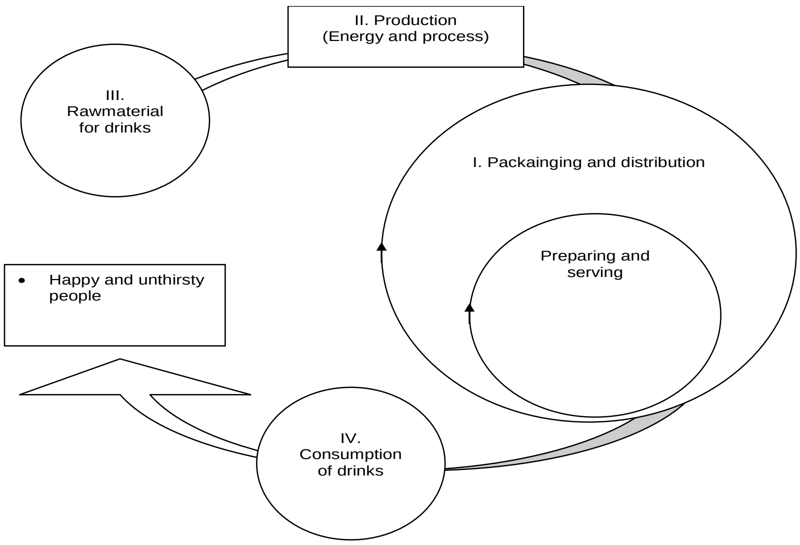


Figure 45 Abstraction of the lifecycles interacting in the drinking systems

Every drink was discussed in a social and ecological perspective. The life cycle of each drink was mapped (Figure 45) and further evaluated in both a qualitative and quantitative way. The process exposed complex cultural and environmental challenges concerning the development of new system and product solutions.

Results

The quantitative data

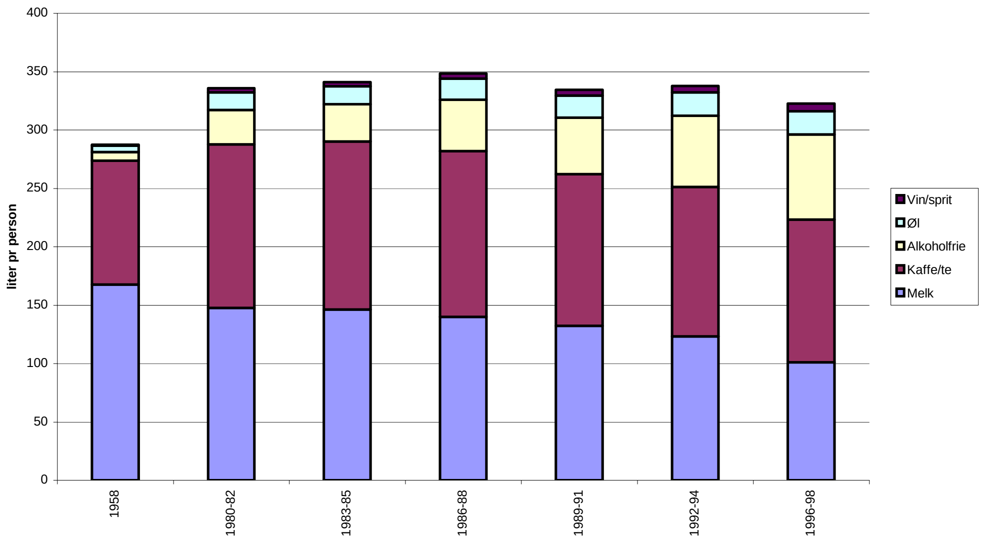


Table 13 Trends in the consumption of beverages in Norway 1958-1997 (Source: SSB) (Hanssen et al 2001)

The total amount of consumption is relatively stable during the last 40 months (*Table 13*). The most visible changes in the consumption patterns is the decrease of milk consumption and increase of mineral water consumption.

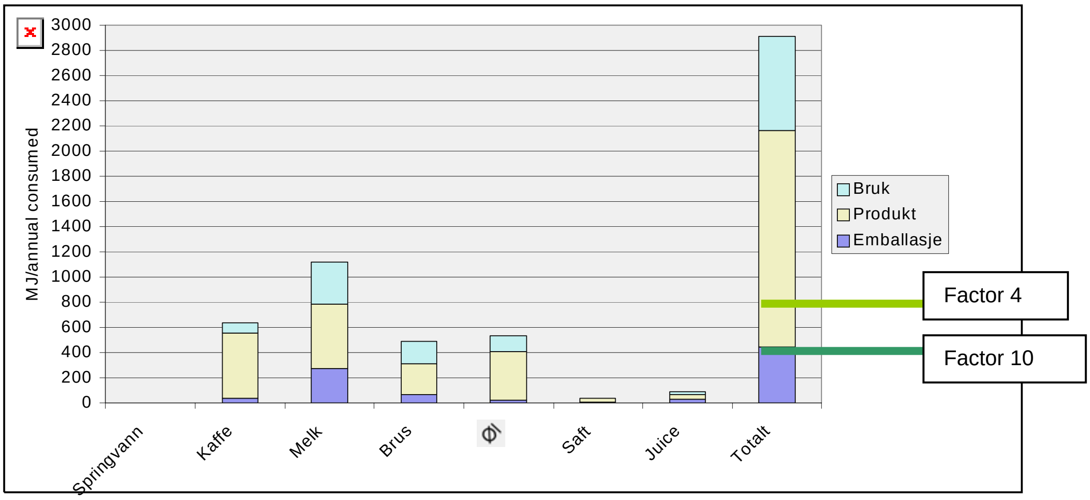


Table 14 Factor 4 and factor 10 levels for the sector of beverage systems in Norway with respect to the energy consumption. (Light blue: consumptions; yellow: product; dark blue: packaging)

The major impact from the different beverages comes from the agricultural processes where the ingredients have their origins. For milk 55% of the energy is consumed in the operation of the farm, 23% of the energy is needed in production of equipment, 18% in the milk production and 4% of the energy is consumed by transportation via the dairies (*Table 14*).

Scenario building based on the VIP-method and solution discussions

As a common platform the project group brainstormed on the theme sustainable development, to find some keywords on which, the new concepts should be founded. Further, the project group invited additional people to be part of story writing for future solutions based on three directions (visions in product design, VIP (see ch. 3.2.3).

The writing session was facilitated by (at the time) PhD student Erik Lerdahl. The industrial designer and lector Per Finne (*Illustration 13*, *Illustration 14*, *Illustration 15*) had prepared drawings and pictures as inspiration for the story writing session. Every written story included ideas for new solutions. These were not discussed further in the pre project, this could however have been done to emphasize the consequences of the methodology in higher degree.

The emotional - heart

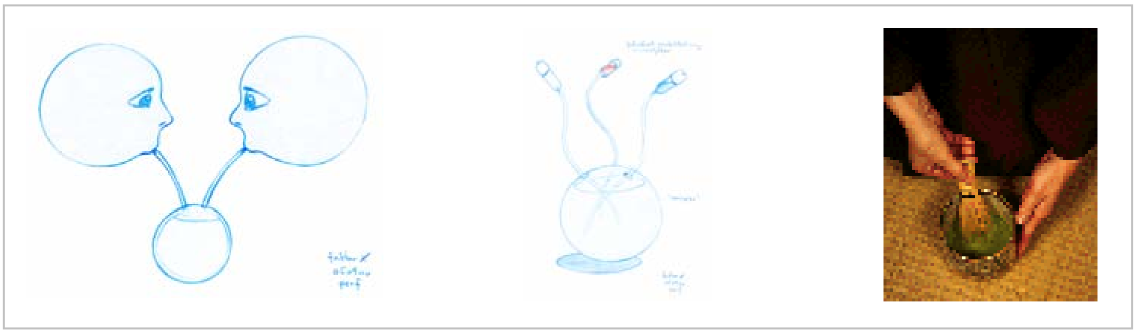


Illustration 13 Solutions in the emotional atmosphere where characterised by "back to basic" solutions, natural collective solutions like small sized farming and breweries in the neighbourhood. (Drawings: Finne, 2000, in Hanssen et.al 2001).

The pragmatic - stomach

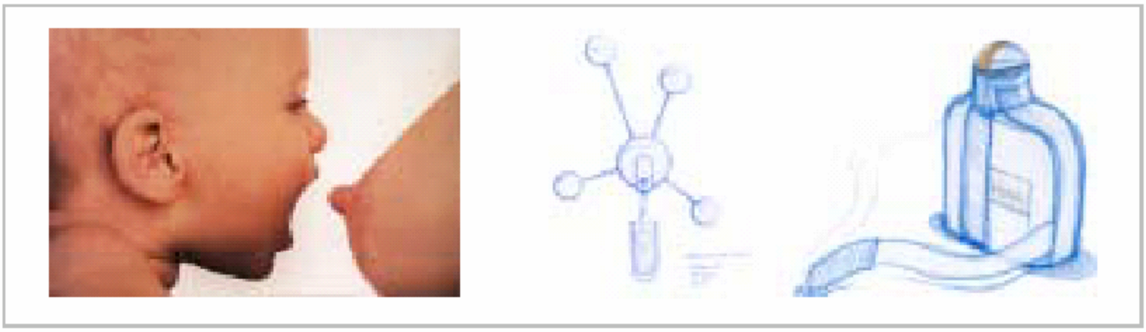


Illustration 14 The pragmatic approach lead to practical mixed solutions. One solution suggested a personal drinking bottle which could be refilled at different vending machines or simply with tap-water. (Drawings: Finne and Wigum 2000, in Hanssen et.al 2001).

The rational - brain

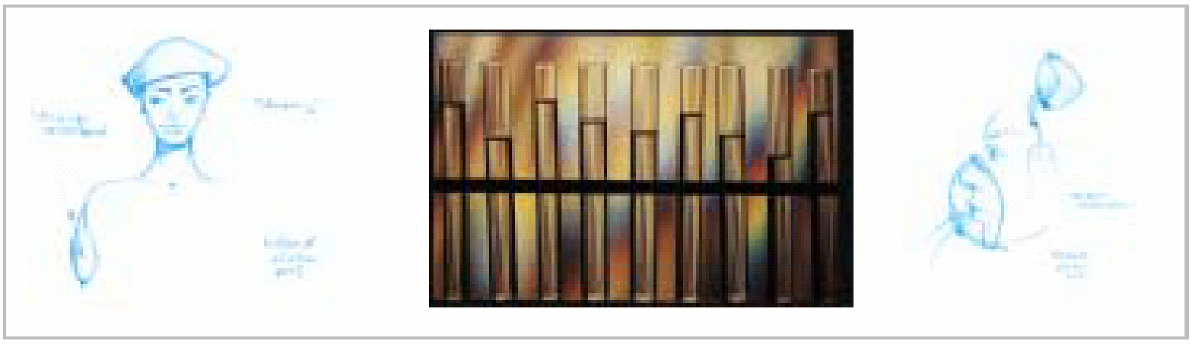


Illustration 15 The stories from the rational world contained solutions based on centralised solutions, for example fresh water transportation through old petroleum pipelines from The Norwegian coast to the central Europe. The physical and health needs where given priority also in the situation of drinking the actual beverage (Drawings: Finne, 2000, in Hanssen et.al 2001).

Vision for a Factor 10 Drinking system is based on:

- A consumption, which in more or less degree is covered by environmental and resource efficient beverages.
- A transformation from an industrial to a more natural based agriculture for production of basic ingredients for beverages.
- Distributed production at the consumers location based on concentrated products replacing the distribution of “ready-to-drink” products.
- More efficient production and distribution of drinking water coordinated with user needs.
- A eco-efficient kitchen saving reducing water and energy consumption.

Table 15 The vision of the new Factor 10 Drinking system in Norway (Hanssen et.al 2001).

The pre-project did not complete the project plan, but provided a solid base for the main project, which to some degree fulfilled the total plan from the pre-project.

5.2.4 The main project

Process

This project was built on a new process strategy involving longer project meetings with 2-3 days duration for deeper study and cooperation between the main stake holders in the project. These meetings were not held as frequently as in the pre-project.

Communication process

-Interactive project website
-E-mail
-Physical Meetings
-The meetings where frequently as about every third month

Introduction seminar and working seminars in the wilderness

One of the important aspects with this research project was to create trust and openness in the process, especially in the work with future scenarios. The project started with a seminar at “Høvik-Odden, Hennie Onstad senteret”, close to Oslo, where all related business to drinking systems was invited. After short introductory sessions, the seminar participants were asked to contribute to the visions of the future development.

The core project team continued the work two days after the seminar, to systematize the new material. Later three more sessions were hold to develop the future scenarios in detail. Parallel to this work,

trends and environmental issues concerning the different drinks were mapped by three of the researchers.
In the process of writing the final report and experimenting with the use of design process in order to connect the future scenarios, analyses and strategies, a last working seminar was held. Here the PhD-candidate participated for the first time in this main project.

Closing seminar

The total results where presented at Høvik-Odden, where additional stakeholders were invited to comment and discuss the results. The report was taken in account the input from this seminar.
All together the project contained 6 seminars.

Documentation

The pre-project and the main project resulted both in written reports based on the research layout. Articles were also written for different international conferences and journals.

Methodology:

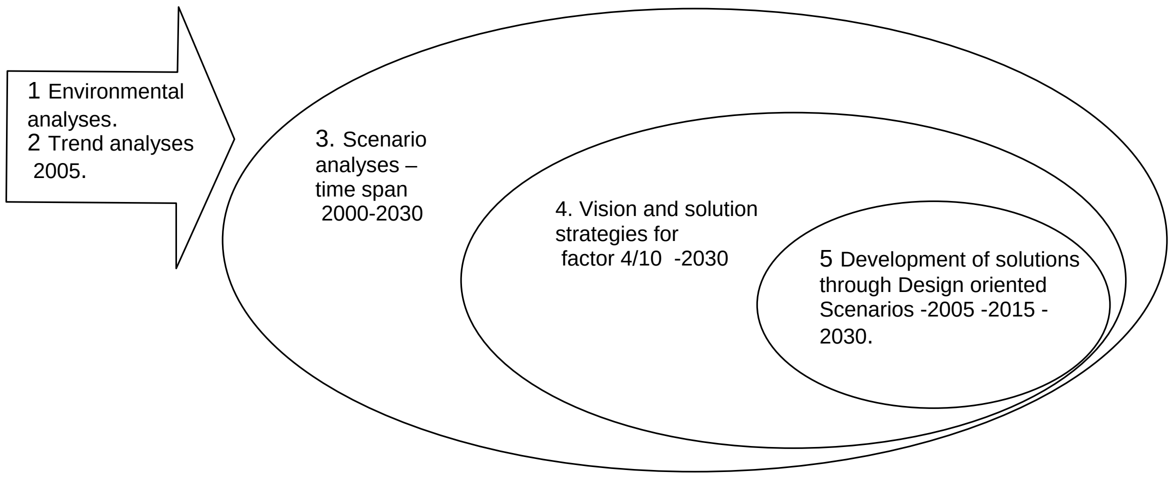


Figure 46 Different methods applied in the study composing a new methodology (Hanssen et al 2004).

Figure 46 was presented in the beginning of the project to indicate the steps in the methodology. It was constructed by the PhD candidate on bases of the suggested methodology from the project leader, Ole Jørgen Hanssen.

Results

Stage 1 and 2: Use of LCA and statistics, study of trends

Environmental impact and Life cycle studies
Both the pre- and main-project were consuming much time and effort on the analysing phases, stage 1 and 2. The process had additional to the results, a function of involving the participating companies and creating awareness of their own business placed in a new system an environmental perspective.

Nevertheless, the data-collection is evaluated as rather unsatisfactory related to the lack of lifecycle data from many of the relevant stakeholders in the drinking system. This is partly caused by a resistance in companies that are not part of the research as such, to spend time on preparing data. It might have a connection to pedagogical aspects “why should we contribute to this project?”, but also the fact that the data does not exist in a proper archived state.
Milk is one of the products with the most complete data. This must be therefore considered when milk actually is characterized by one of the highest ecological impact values in comparison with the other

drinks. The packaging is not representing a considerable impact, whereas the beverage itself is representing the major impact, and here especially drinks based on raw ingredients from the conventional agriculture, such as coffee, milk and beer. When these data are evaluated, the qualitative aspects are important factors for strategic discussions. Milk is an important ingredient in the Norwegian traditional meals, whereas coffee and beer are social and ritual drinks. Coffee and beer are not contributing to the amount of liquid needed per day for an adult, in contrary the caffeine and the alcohol is dehydrating the body. The consumption of all beverages and water should therefore preferably be evaluated in connection to the total fare of an individual.

Trends and market studies
The prognoses for-seen in the time span from 2000-2005 were forecasted with some major changes. The drinking consumption was expected to go in direction of less milk and tap-water consumption and increased numbers for juice, bottled water and wine. Beer and mineral water was also seen to increase in a small amount. Some specific energy-drinks or functional drinks were expected to follow a steep curve in the consumption, but not to dominate in the total picture.
The trends for packaging point to material recyclable non-reusable bottles. There is also an increasing use of al-boxes for beer and mineral water. Bag-in-box is more frequently used on larger volumes, but otherwise will paper board still be dominating the Norwegian market considering milk and juice.

Stage 3: Future Scenario building
Based on the Delphie methodology for scenario building (Ringland 1998), nine dimensions of the society and world premises were discussed and the framework of 4 major scenarios was created. The scenarios characterises four areas of development, which already can be found in certain countries, sub-groups or cultures today.

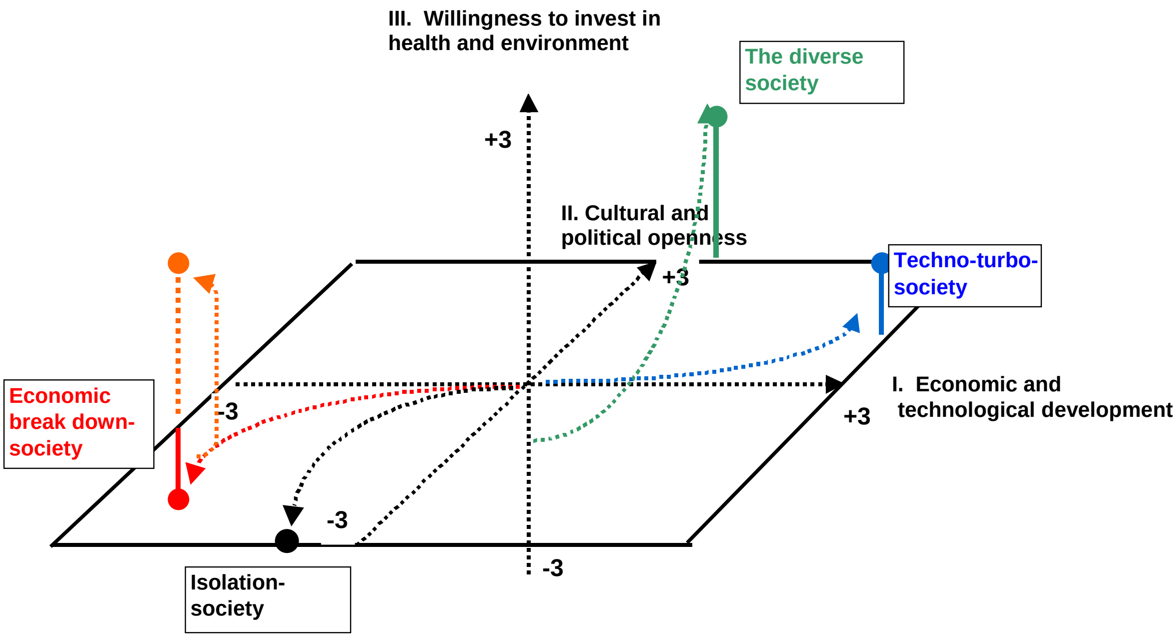


Figure 47 Four possible scenario for societal development towards year 2030; the Techno-turbo society, the Diverse society, the Economic break-down society and the Isolation society (Hanssen et al 2003).

The axes in *Figure 47* represent the scale from +3 to -3 indicating the priority in the societies in terms of :

I. Economic and technological development
II. Cultural and political openness
III. Willingness to invest in health and environment

The four scenarios represent different profiles that can be connected to human characteristics, life style, focus and preferred material solutions (Table 16).

Scenario	Characteristic user situations and human personalities; life phases, life situation and lifestyle	Typical product/systems which might be representative in the scenario
1. Technological optimism (Turbo-techno society) High technology in focus and great fascination of the digital and synthetic.	• Dominating age 20-35 • Desirable with many and more superficial social relationships • No Children, travelling and outdoor life • Self realisation through work and technological networks • Dining out with or without friends	• ”Smart-house”, • Small electronic and mobile units for communication, work , security etc. • Data-chip pin on the body to measure the ozone layer, sun and emissions
2. Cultural and political diversity (The diverse society) Great variation between high- and low-tech solutions. Individual contribution is characteristic for the products and systems	• 50-70 years of age is dominating the society from ca 2015-230, multicultural backgrounds • High interest for other cultures both in work and private • Winter-tourists in warmer countries • Much work in NGO’s • Focus on sharing facilities • Good economy	• Service products is commonly used • Public transportation has high priority • Focus on justice, ecology and high quality
3. Economic breakdown (The Buble broke) Simplified solutions, preferable are low tech and minimised product life cycles, such as personal owned packaging brought to the stores.	• Lower education • Less travelling, high involvement in local conditions • Focus on own loved ones (family and friends) Closed outwards, but more open inwards (socially and political?) • Low budget with focus on basic needs. Traditions and roots have re-entered peoples life	• Basic resources such as seafood and fresh water have high value • Total productivity (including unofficial) is the base for GNP • Less technology focus • Local solutions have high priority in substitution for centralised systems • “nature-products”
4. Increased insecurity and vulnerability (The isolation society) Advanced control and use of high-technology to secure the quality of all systems, e.g. organic recycling. Security has a higher priority than economy and ecology.	• Protectionist attitudes • Personal development is reduced due to insecurity and fear for the future • Meals are enjoyed at home, only lunch at work	• All products are “security-declared”. This includes food and other types of products. • Close and loyal relationships between producer and consumer • High-tech mobile control-equipment is just as common in 2003 as the cell phones in 2003. • Synthetic secured production processes are preferred rather than products from natural processes.

Table 16 The table is placing the four main scenarios and their characteristics concerning human focus, in connection with different priorities of products and systems which are likely to occur in the different “futures”.

Scenario building will in this project exhibit the possible climate for product and system development. Within these scenarios the businesses will find different premises and drivers for development of new solutions. Each scenario represents unlike values which promote demands for different qualitative principles in design solutions (Third row Table 16).

Stage 4: Focusing through vision and presenting strategies

The vision for a new drinking consumption and total system

Vision:

Develop a beverage system, which covers the consumer's physological and nutrient needs, which captures the social and cultural values and is at least 10 times more environmental and resource efficient than the solutions of 2002.
This can be concretisied by:

I. We should drink as much clear water as possible, favorably spring water which is locally produced and efficient distributed through the pipeline system, supplemented by products which contributes with the necessary amounts of nutrition, vitamins and minerals.

II. We should choose products, which provide the lowest environmental and resource impact, which contribute to a social justified distribution and which are based on ethical practices considering their production and distribution, specially cerning the extraction of raw ingredients and materials from the agriculture.

III. The system should use packaging, which is as environmental and resource efficient as possible. This means solutions which include a minimal loss of product in production, and reuse solutions with efficient and maximal material recycling of disposed packaging.

Table 17 The vision of the new factor 10 beverage system (Hanssen et.al 2004)

The vision was rewritten during the project and once again on the last working seminar (*Table 17Table 18*). It was a goal to make it as self-explaining as possible. The vision was presented in the report as an own chapter consisting of one page. The vision should guide the direction of strategies for new system solutions.

The original Norwegian vision:

Visjonen:

Utvikling av et drikkevare*system* som dekker fysiologiske og ernæringsmessige behov hos forbrukerne, som oppfyller sosiale, kulturelle og helsemessige funksjoner, og som er minst 10 ganger mer miljø- og ressurseffektivt enn dagens løsninger.

Dette kan konkretiseres gjennom at:

IV. Vi bør drikke mest mulig rent vann, og fortrinnsvis springvann som er lokalt produsert og effektivt distribuert gjennom ledningsnettet, supplert med produkter som gir tilskudd av nødvendige næringsstoffer, vitaminer og mineraler.

V. Vi bør velge produkter som gir lavest mulig miljø- og ressursbelastning, som bidrar til en sosialt rettferdig fordeling og som er basert på etisk forsvarlig virksomhet i produksjon og distribusjon, særlig i fremstilling av råvarer fra landbruket.

VI. Det bør benyttes emballasje/distribusjon som er mest mulig miljø- og ressurseffektiv. Det innebærer løsninger som gir lavest mulig produkttap i distribusjonen, ombruksløsninger der dette er mest ressurseffektivt, og størst mulig grad av materialgjenvinning for brukt emballasje.

Table 18 The Norwegian original vision (Hanssen et.al 2004).

Strategies of improvement on four main areas

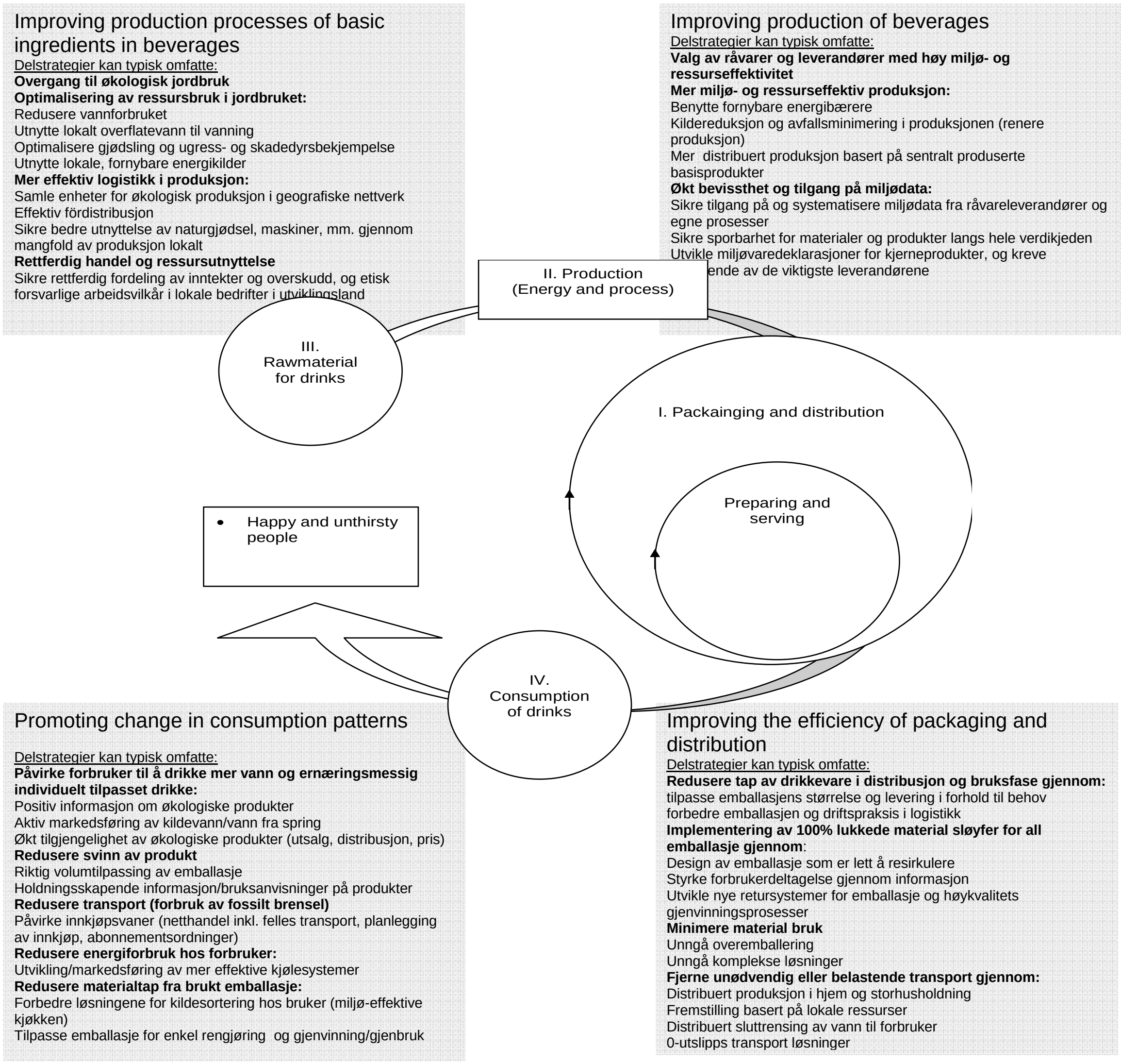


Figure 48 The strategy areas are given priority depending on the co-operating companies and their possibility of influencing and changing the system and product solutions.

The four areas of strategy improvements are (Figure 48):

- Improving production processes of basic ingredients in beverages (priority III Rawmaterial for drinks).
- Improving production of beverages (priority II Production).
- Improving the efficiency of packaging and distribution (priority I Packaging and distribution)
- Promoting change in consumption patterns (priority IV Consumption of drinks)

The data-analyses provided the project with numbers and comparisons of the different areas of the system, revealing that changes in the consumption patterns and improvements in the production of agricultural basic ingredients will reduce the total environmental impact the most. A simulation made in the closing phase of the project (*Table 19*), indicates that it is possible to achieve a factor 10, if the drinking behaviour pattern consist of to a high degree tap-water, which is replacing coffee, beer, mineral water and partly milk (set to min. 90 litre per capita)(green colums). Bottled water is not as promising as replacement (the read colums). Although packaging is not a major environmental impact in total, in this accounting it is more energy-demanding than use of the pipelines for municipal water distribution. In the “Bottled water”-simulation there will be no room for other drinks if milk is set to a minimum of 90 l per capita and the rest of the physiological need for liquid should be satisfied by bottled water. This anticipates that the production or distribution is executed as in 2001 with no new environmental improvements.

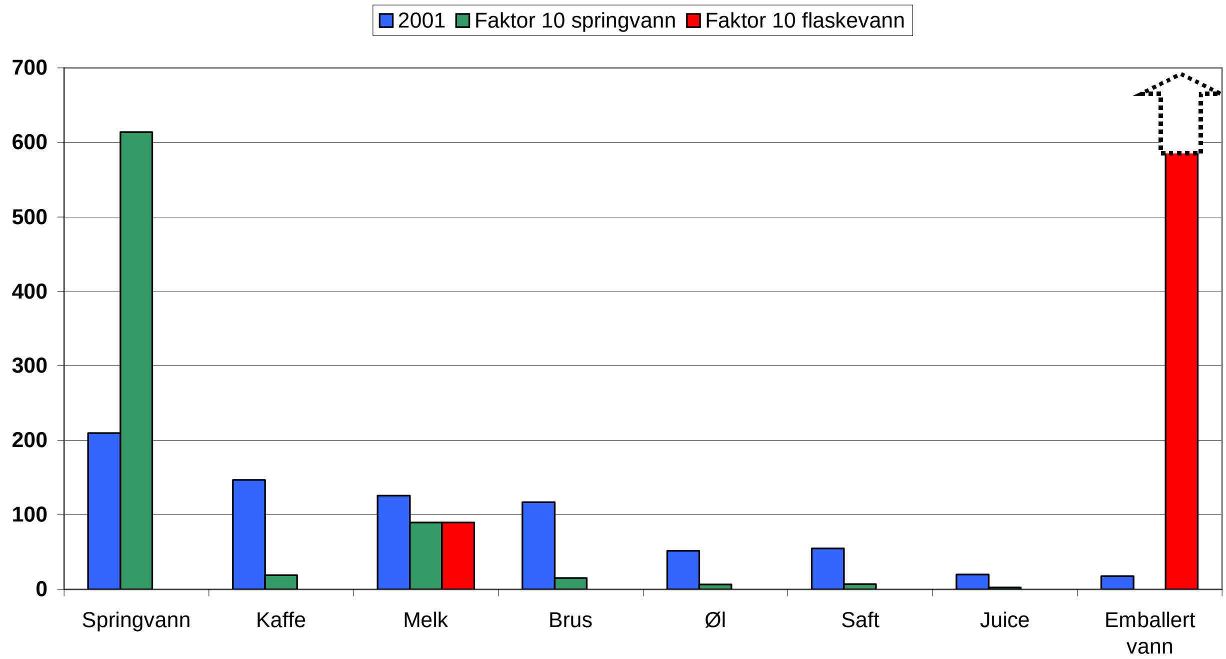


Table 19 Scenario for the distribution of drinking consumption if the goal of factor 10 development should be realised through a new profile of water consumption patterns. (Blue colums: status 2001; green colums: Factor 10 simulation based on tap water(springvann); red colums: Factor 10 simulations based on bottled water (emballert vann/flaskevann)) (Hanssen et.al 2004).

In contrary to this theoretical simulation, new solutions for drinking systems for the real world should favorably be designed in a more total picture, including food and behaviour connected to the consumption of food stuff.

Stage 5: Exemplifying solutions through Design Oriented Scenarios (DOS)

This phase was done solely by the PhD candidate in the closing phase of the main-project. Material was taken from the working seminars and used as basis. A part of the research was to understand the material and design oriented consequences of the scenarios and environmental analyses. Through discussions with the project leader and the project group, some Design Oriented Scenarios (see ch. 3.3.3) were developed as visual and concrete examples. Three strategy areas were chosen and additionally one problem focus within each of these areas was presented in connection with each of the future scenarios (Figure 47). A solution oriented approach was then related to the profile of each scenario.
For improvement of packaging and the material loop-closing (strategy priority I), the kitchen solutions and packaging and recycling system were evaluated in parallel for a more holistic idea generation (Table 20).

Scenario/ product and system area	Design of packaging	Chosen principles for the recycling system	Kitchen solutions for loop closing
1.Optimistic and technological atmosphere (Turbo-tech society)	High-tech focus is dominating and the fascination of digital and synthetic solutions is large	Different stakeholders gather the sorted material(waste) available	Use of data chips, biotech and decentralised processors, favourable placed in the private homes
2.Cultural and political rebirth (Society of manifold)	Large differences between high- and low-tech solutions. The packaging is characterised by the content.	A manifold of solutions is possible through individual concepts and deals with stakeholders and responsible authorities	Combination between digital, biological and manual solutions for high flexibility. Service solutions frequently used
3. Economic brake down (End of the Bubble)	Simplified low-tech solutions and minimalistic lifecycles, such as private owned	Private delivery to local connection points, developed with high functional and esthetical value	Manual systems based on clear visual labelling for local sorting and gathering/delivery. Reduction of waste as main focus
4. Great unsecurity and vulnerability (Society of isolation)	Use of high-tech solutions to secure the quality and avoid sabotage of the system. Security has highest priority.	Automatic gathering of all material and waste, sorted by professionals for further sale and use.	Computer technology, centralised and automatic, system, minimal responsibility placed by the private household.

Table 20 is presenting the Design Oriented Scenarios connected to the different profiles of the future scenarios.

The table of parallel idea-generation was visualized through sketches for further discussion (*Illustration 16*).

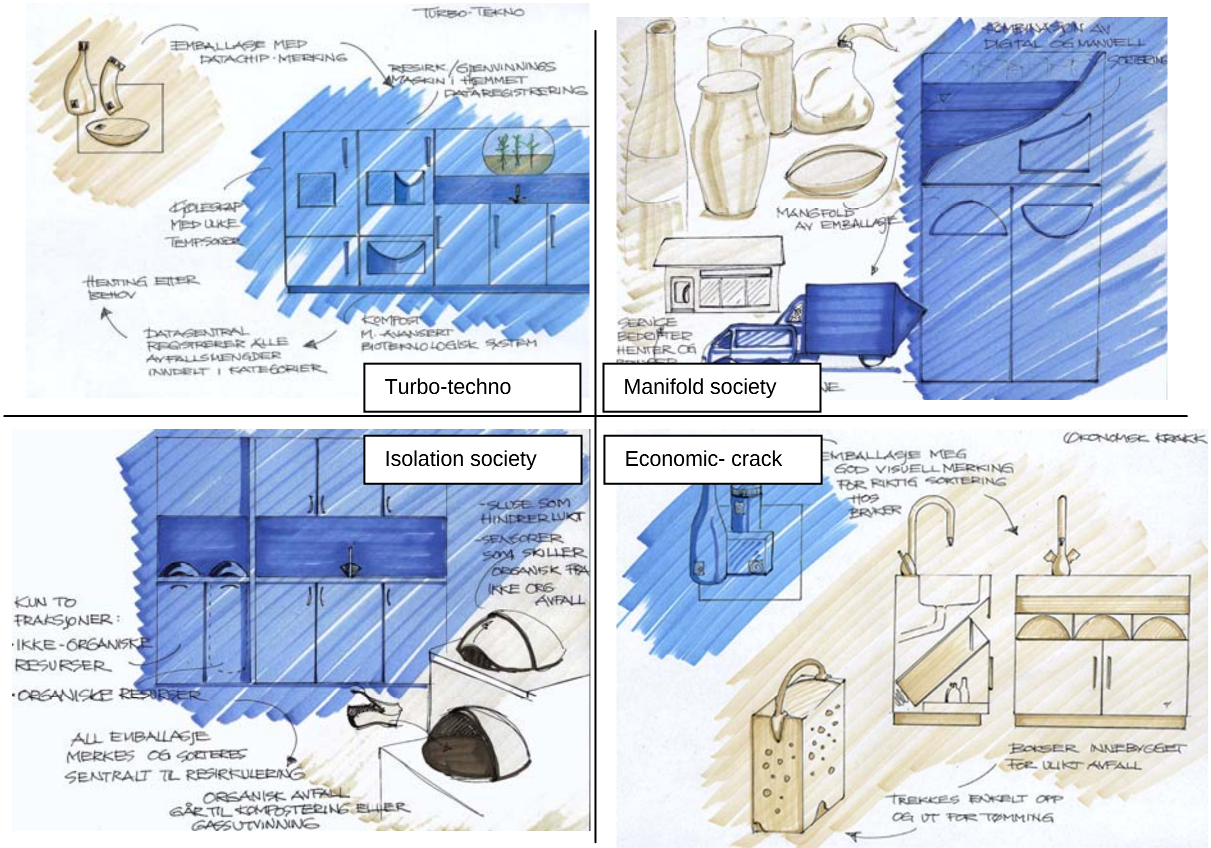


Illustration 16 The sketches show a quick idea generation based on the table of the four scenarios and connecting principles for packaging, recycling and kitchen solutions. (Wigum 2002, in Hanssen et.al 2004)

The main project closed with a final seminar, where the analyses, scenarios, strategies, vision and Design Oriented Scenarios where presented. The seminar included a short workshop, where all the participants evaluated their interest in the different strategies for further work and realization of new solutions.

Evaluation of the scenarios in the closing chapters of the work

The final work, mainly executed by the project leader, was to evaluate the different scenarios, e.g. to in what degree they were promoting a climate for sustainable-system and product solutions. The diverse society based on openness both politically and culturally, and the high personal involvement in societal tasks, seemed to be the most promising. The concluding discussions therefore recommend a conscious co-operation with political departments and other legislative organisations that are influencing the premises for industrial activity and market demands.

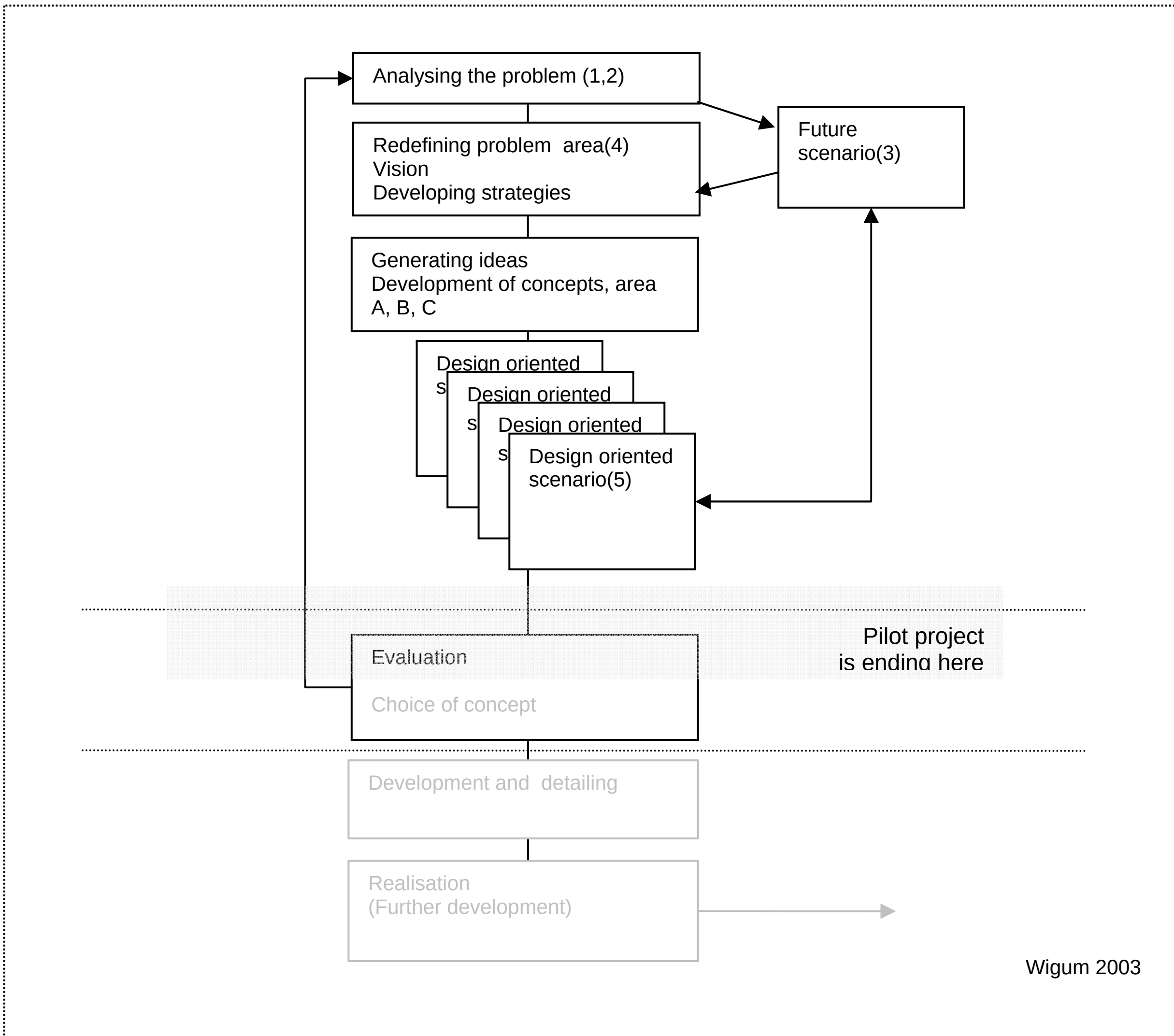


Figure 49 The process is reviewed after closure. The numbers in the figure are referring to the stages in the methodology presented in the initial part of the main-project (Figure 46).

5.3 Student contributions and experiences with factor 10 design approach

(These results have also partly been presented in the paper:
Jakobsen, Mette M. Wigum, Kristin S. "Sustainable Services & Systems - 3s, and the impact on ecodesign education". Amsterdam: Towards Sustainable Product Design 6th International Conference, 2001).

5.3.1 Advanced courses

Thinking broad and radical in the design process to meet the future challenges
During the last 5 years, master level students at the Department of Product Design Engineering and other departments at NTNU, had the opportunity to do their graduate work connected with the research project "Factor x" ; both the pre- and main- project previously described.
7 design/machine engineering students have done their master thesis based on the Factor x concept, and their results and experiences are interesting to discuss in connection with a wider perspective on eco-design involving both level 3 and 4 in the eco-design ladder of Brezet, Cramer and Stevels (*Figure 7*) The students have worked on different themes, such as future office system solutions (Heggelund, Mære, 1999), (Dragsund, 2000), (Stave, 2001), the sustainable kitchen (Hammernes 2000), and the

sustainable bathroom (Amdal 2000). Three other students have worked specific on the drinking systems, such as packaging and distribution of water (Lier 2001).

The final product concepts are designed with help of system thinking

The products from the student master thesis' need to be seen in a wider perspective. The user activity, which the final products invite to, is the most interesting aspect of the products, and this aspect includes *the context* of this user activity. As an example, the new office furniture solutions are meant to contribute to a decrease in the need of office area (*Illustration 17*). The kitchen product invites us to reuse our semi-dirty dishes and cups, before they go into the dishwasher. Both new solutions are parts of a different thinking and new activity patterns.

The bathroom product concept is a bathing tub for small children and babies(*Illustration 18*). It makes it possible for grown-ups and small children to have a bath together, to share the experience of being in relation to the basic water element. It further has additional functions, such as storing possibilities, a sitting function and surface for childcare. Both the kitchen and bathroom concept is developed in co-operation with a large company, which is promoting certain types of lifestyles through their products and product series. A system approach gives the designer a possibility to work with a broader perspective. Although each single product must be considered concerning materials, energy and toxic emissions, the product seen in a wider context can more radically decrease the total ecological impact. This is where the service systems can contribute, and here for example as a part of lifestyle promotion. It may be even easier to imagine the concepts of services included in the office solutions, though. Companies as customers are already familiar to renting and leasing systems for different products and functions.

Illustration 17 (Stave, 2001) The user, activity which the final products invite to, is the most interesting aspect to the products, this includes the context of the user activity. The new office furniture solution, X-tra, is meant to contribute to a decrease in the need of office area. The student invovled a study of different company development trends as e.g. the "hot-desking-system", where there are less working areas than employees.

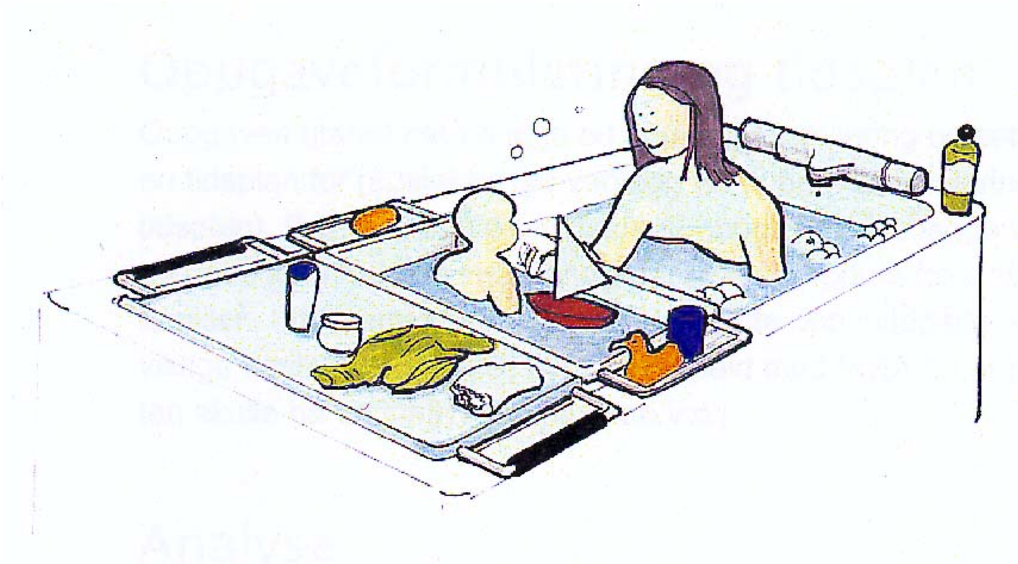


Illustration 18 (Amdal 2000) The bathroom product concept is a bathing tub for small children and babies. It makes it possible for grown-ups and small children to have a bath together, to share the experience of being in relation to the basic water element.

Starting with a need, desire or human activity

The factor X design process differs from traditional eco-design by looking at a situation in society or at a concrete ecological problem as the starting point. There is in the beginning no reference product, but there may be ”reference functions” in a broad sense. As an example, the future office solutions focused on the working functions. The sustainable bath was rooted in the use of water and energy, within the context of basic needs and social contact between adults and children (*Illustration 19*).

These needs, desires or functions are then placed in a global perspective, looking at the environmental impact connected to existing solutions, the history of the different product solutions and the future drivers for new solutions, with the focus on human ”real” needs. This part of the introduction phase in the design process is a challenge to the student, since there is a lot of interesting material to work with be. To use the broad variety of information, and explore the most interesting possibilities and directions for future solutions, scenario building has been a good method within the projects. It is further important that the student has an accurate time schedule to follow in this phase.

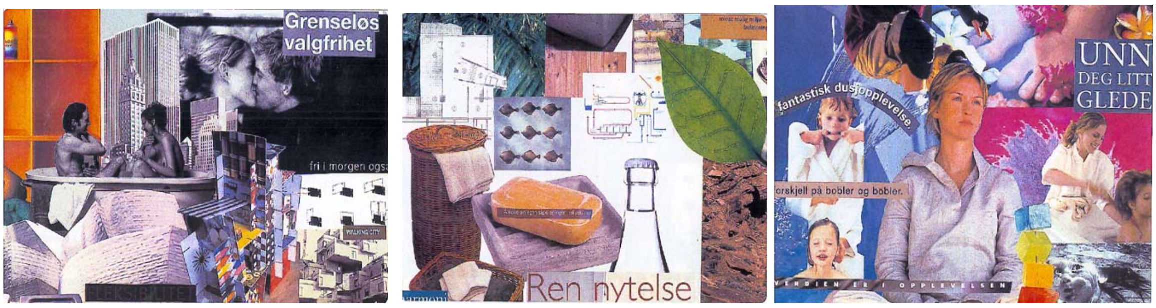


Illustration 19 (Amdal 2000) The first scenario characterises the future through flexibility and few boundaries, the second scenario describes a new consciousness and closed loops, the third scenario focuses on experiences and emotions. The further sketching of ideas was done by the student, freely based on impulses from these three scenarios in connection with more concrete criteria.

Two of the students where strongly occupied with a Factor x methodology in their work (Dragsund, Hammernes 2000). They defined this first phase as the ”Gas”-phase, which was followed by the ”Fluid”-phase and finally ending up in the ”Solid”-phase. The first part of the project shall give a greater perspective to the further development of the new solutions, and reduce the risk of only considering incremental improvements. In cases, where the solutions may be lifted to a higher level and perhaps involve new drivers, functions or products, this first phase is of great importance. A Factor x methodology contains the work with scenarios and visions, which is important input to the companies, mapping some of many possibilities for new solutions within holistic thinking. To see the situation in the light of the global totality shall finally lead to a decrease in energy and material consumption, not only considering single products, but the lifestyle per capita.

5.3.2 Required Eco Design Course

Spring 2003 the students in 6th semester where given the four future scenarios described briefly in session 5.2.4, and the task to develop a future concept for grocery shopping within the different climates of the "ready-made" scenarios from the main pilot project. The students worked in five groups whereas two groups focused on The isolation society and the other three groups had each one of the other scenarios as basis. The group work contributed to a wide discussion of new systems and products. However, initially the students were confused in terms of the task they where given, and how they should approach a service and system, rather than a single product (see some of the results in chapter 9.4.)

5.4 Reflections for further approaches

Concerning the advanced courses, connected to the Factor x - thinking, parts of the conclusion from the projects is, that the work must not be presented too abstract to the companies that are involved in the projects. The scenario building should involve working hours from important players from the company, and not be done only by the student/designer. The process in scenario building is almost just as important as the results, since this process should create ideas and understanding, which reveals business opportunities in this new way of thinking.

The use of existing scenarios by the undergraduates was also only partly successful, and neither gave the students enough experience developing such, nor enough ownership, which might have promoted a stronger progress in the development and design process.

The broad approach was to some extent very demanding for the students, and the final specified products did therefore not reach the level of detailing as far as it could be desirable. The presentations of the products were therefore very much depending on the more abstract part of the project, which often can be hard to communicate.

It should be underlined, however, that most of the students have executed impressing work considering their wide perspective approach. Especially the master students, but also some of the undergraduates have shown mature understanding of the sustainability issues, and of the relation between human life style and ecological challenges.

The student projects differ from the pilot study in terms of a clearer user-focus and a deeper study of actual needs. The pilot study has, however, a stronger environmental profile and a border crossing approach in terms of company co-operation and system thinking.
To estimate the time scale in future scenarios and introduction of new concepts, seem to be closely related to the actual state of the companies' responsible for the development and the maturity and expectations in the market. For some solutions, a necessary transformation of infrastructure or lack of technological solutions are expanding the demanded time perspective.

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6.0 Case study: The Olympic Winter Games Lillehammer ’94

The research aim for this choice of case study is to evaluate how existing knowledge from other design projects on a system level can be useful and hence transferred to new factor 10 design methodology. This case study, the Olympic Winter Games Lillehammer ’94 is characterized by a holistic visual profile founded on a set of specific values. These values where chosen to represent Norway in a modern and typical view; in addition to the values of the Olympic tradition. The manifold of activities, products, services and sub-systems were designed and organized directed by an overarching Design programme and Design manual. Numerous of companies cooperated and took part in the realization of the Winter Games. They followed the Design programme in order to contribute to a finally holistic solution. This methodological approach could be followed in design for sustainability, where short time projects (within a 5 year time limit) are completed within long term goals and intended consequences (in the factor 10 direction). The values to guide this type of projects would then be founded on sustainable principles, guidelines and criteria.

The case study is supported by a short description of DSB (the Danish Public Railroads) and their change of profile and organization structure. This change was initiated in order to meet new conditions in the open market of public transportation services. This reference project is revealing how a change in business strategy, require a strong vision which must be supported by new design themes (or visions) and design strategies. This change process has so far lasted for seven years. It exemplifies the complex process of changing the profile of a traditional company and organization. The Lillehammer ’94 design process had duration of four to five years, from initiation of the working teams and till the Winter Games closed after successful performance.

The target groups for this research is product and system design initiatives in new business/ organization networks, but also initiatives on strategic level in established businesses and organizations.

6.1 Research questions related to case study

The reason why the The Olympic Winter Games Lillehammer ’94 is of interest with connection to the research questions in this thesis has at least four aspects:

Research questions
Q1 How can product and system concepts be designed to promote a factor 10 development?
> **Q1a** Can connected functions and experiences serving the end-user, be the starting point of co-operation between the main stakeholders, rather than the products themselves?

1) The Olympic Games of Lillehammer had a great experience as focus and final goal. The new solutions were primary designed for specific activites (sports), communication (media), and audience.

The study of this process may provide useful data to this change in focus, from product to user. The DSB reference case tells about a company organization which actually did this exact switch; from equipment (material) focus to passenger (user) focus.

> **Q1b** How could a new methodology include the long term perspective and the short term steps coordinated in the development of new concepts, and in the setting of a company and/or organisation?

2) The projects are practical example of how systems, products and services are designed and launched through a cooperation of many different stakeholders to reach a holistic total solution. The projects are rather short term initiatives, but contain system fous and long term perspectives. The context of the design approaches is both an organization within a large network and a company.

Q2How can design concepts be evaluated in the early phases of the design process, concerning their ability of contributing to a future development in a factor 10 direction?

> **Q2a** How are the different principles of sustainability, guidelines and criteria defined for the new concepts?

3) The project (Lillehammer ’94) is based on a vision defined early in the project through a tedious process of communication and development of a conscious design management

> **Q2b**How will the principles of sustainability, guidelines and criteria enter the design process to promote and evaluate future factor 10 solutions?

4) The project (Lillehammer ’94) is using certain methods and a methodology to maintain the visions of expression throughout the project and into the final results (systems, products and services).

6.2 Materials and methodology; data collection

6.2.1 **References**

The Design Programme and manual, 1991
The original manual and programme can still be bought as the Olympic Museum in Lillehammer.

Moshus, Petter T. *Designprogrammet for OL –Rapport om designprogrammet for De XVII Olympiske Vinterleker Lillehammer 1994*. (The Design Programme for Olympic Games – Report about the Design Programme for the XVII Olympic Winter Games Lillehammer 1994)

Documents on the internet: Environmental report and organization development and charts

Post project interview (see chapter 7)
Head of Design in the Lillehammer Olympic Organisation Committee (LOOC) and the coordinator of the external design team, DesignGroup ’94 ANS, have been respondents in deep interviews. Head of Design has also read and commented on this chapter, which is describing the design process, results and organiational facts.

6.3 Results and summary from the references

6.3.1 Placing design management on the agenda for the Olympic Winter Games Lillehammer’94

The proposal for having Olympic Winter Games in Lillehammer was accepted in 1989. The committee, which worked for the proposal preparations introduced a few visual elements that became the starting point for longer discussions of how design of different types (here graphical design) should be managed for the Olympic Winter Games Lillehammer ‘94 .
The consultancy bureau Engen & Harlem, which had been involved in the initial design work of an Emblem for the proposal, had a clear idea about the need for a planned and *complete design process* for the final games.

Different important stakeholders were further invited for a culture conference, political “top-meeting” and open discussions in relevant fora, to create an understanding for the importance of using a design group in the Olympic organisation as a hub for total control of the visual expression and manifestation of the vision of the Games.

A report concerning design values and Norwegian identity in The Winter Games ‘94 was made by an interest group chaired by Odd Thorsen, and suggestions for a working model were presented by the design consultancy Engen & Harlem (Moshus s.31) .
A new group of designers, also lead by Odd Thorsen were given the task in spring 1990 to do a pre-project showing the possibilities of design strategies fulfilling the needs for the Olympic Games and presenting suggestions for the total visual direction of the event. This pre-project was not officially adopted by the LOOC, Lillehammer Olympic Organization Committee, allthough Head of Environment in LOOC, Inge Aarhus did also attend this group (Moshus p.32).
The pre-project was based on the signals and proposals from the previous discussions and input from interest groups. Inspiration and background information from another complex design projects, the work with “Norgesprofilen” (“The Profile Norway Project”) and “Sporprosjektet” was used in a high degree.

It was initially planned to employ one designer in LOOC. This person, who eventually was Petter Moshus, was finally appointed at the Section of Information. Moshus, Head of Design, managed to expand both the financial and organisation priorities of the design task for the Winter Games. He used the material from the pre- project (Thorsen et al.) and saw the necessity of a stronger design function in LOOC to implement some of the important strategies which were presented.
Moshus composed an external team of designers to design the *design programme* as such for Lillehammer ’94. This group defined their co-operation as the DesignGroup ’94 ANS (DesignGruppen ’94 ANS) and consisted of Knut Harlem, Åsmund Sand, Sarah Rosenbaum and Reidar Holtskog. In the detailing of the design programme, this group was cooperating with Ashley Both who later in the process, was employed as responsible for the graphical and industrial design in LOOC (Figure 50).

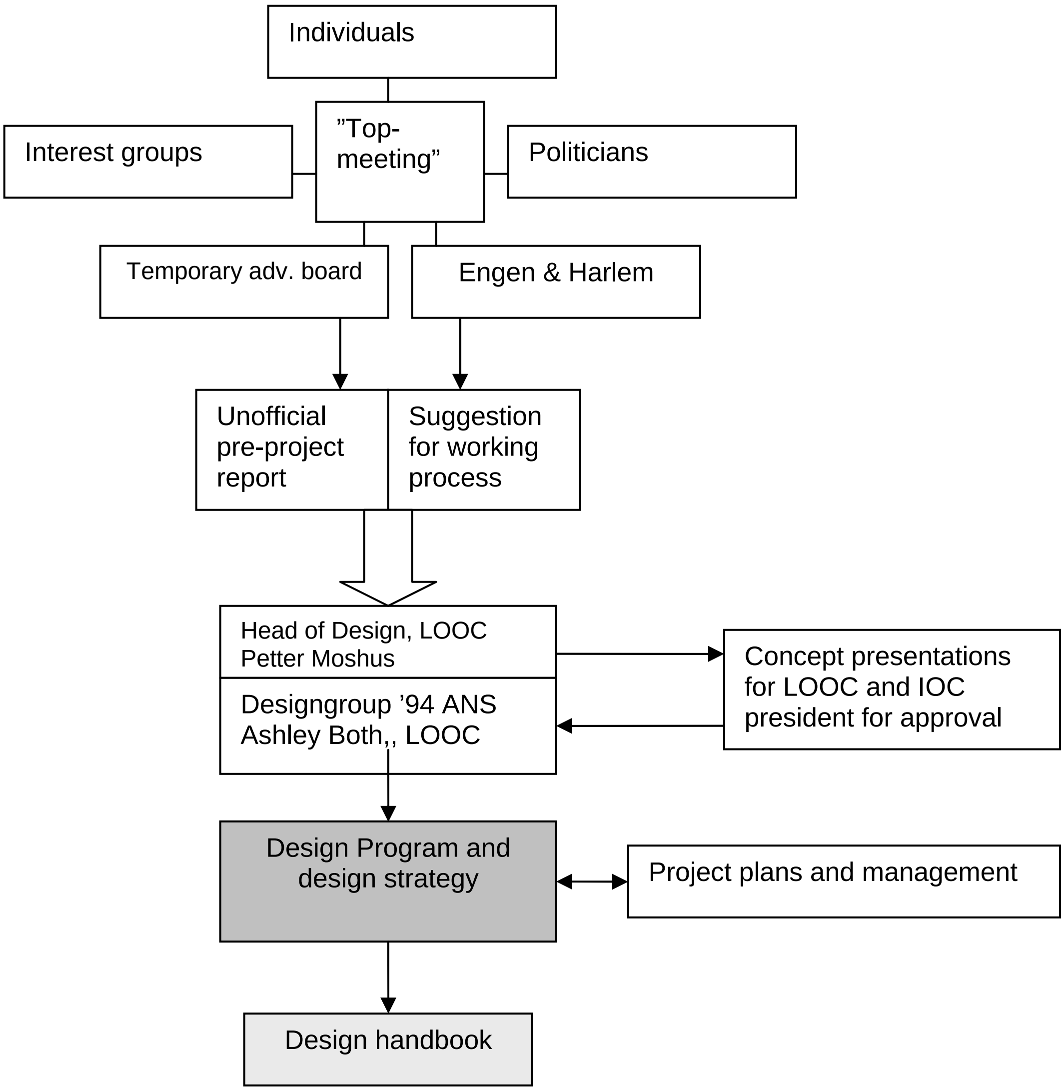


Figure 50 The Design Programme and Design Manual were designed by the Designgroup ANS’94 and the Head of Design in LOOC, Petter Moshus.

6.3.2 Project planning and management

The work on the Design programme, started by formulating

- Goal and scope
- Plan for execution
- Description of needed functions
- Premises for the architectural tasks

Vision and goals were decided to be challenging the entire process and the Olympics as such, but at the same time appear realistic and honest.
In 1991 the vision for the Olympic Games ’94 was in place. Two years after the acceptance in 1989. The summer 1991 the Design Department was given the status to report directly to the Information Section, having representatives in the leading board.

6.3.3 “Business strategy”

The placement of the design function in the organisation was a process, which developed parallel to the introduction of the design tasks and along with the understanding of the importance of a total view on the Olympic’s visual and functional expression.

After the Design group '94 ANS had presented their work and managed to create understanding of the potential in this type of work, the management and dapartment of Design and Architecture were placed on the third level in the organization (*Figure 51*). Design was now seen as the strategic connecting point for details towards a holistic result.

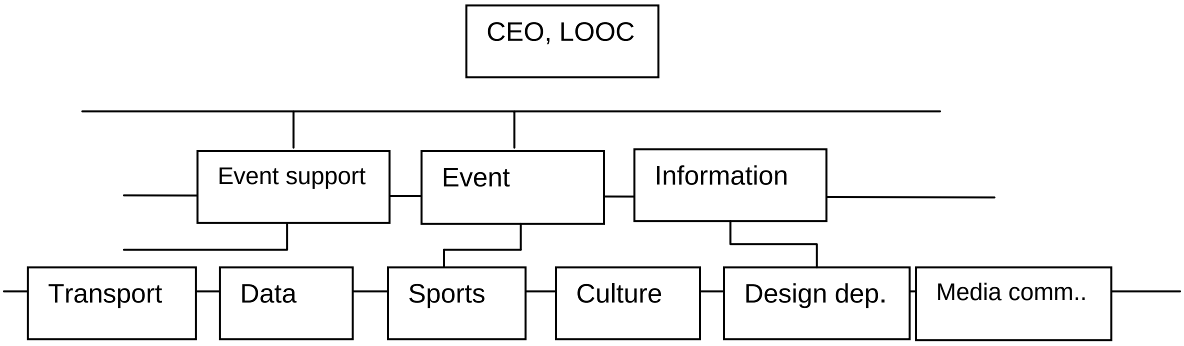


Figure 51 Section of the organisation map (source: www – ombygging av organisasjonen -).

6.3.4 Building a design network

The LOOC organisation had three focuses for the goals for the games
-the aim of the arrangement
-the national aim
-the international aim

Since the president Gerhard Heiberg was interested in the design issues, the content of the design discussions became more important than the formal aspects. It was still a hard and long process to achieve approval both internal and external that the design process was a very powerful tool and of major importance in order to reach a holistic visual profile and a clear identity of the Olympic Winter Games Lillehammer '94.

The functions and tasks of the design department:

1. Responsible for the visual profile and the visual identity of the LOOC organisation.
2. The professional responsibility of the design and architecture
3. Planning and management of the projects; information signs and festival decoration.

Methods, which where used by the design department

- Design program and design politics
- Clarified visual profile in design handbooks
- Use of strategies, work plan and routines for the management of the design program
- Defining the target groups which involved in completing and communicating the visual profile of the Games
- Methods for motivation and building of a design network
- Description of departments as motivator, councilor, service provider and securer of quality
- Recruit
- Internal and external focus on team work and problem solving
- Conscious motivation of external designers in holistic thinking
- Initiating design based product development processes between departments in LOOC, co operating partners and Norwegian designers

The designers in LOOC changed between the roles of being the leading part in defining the design conditions and being the practicing designer.

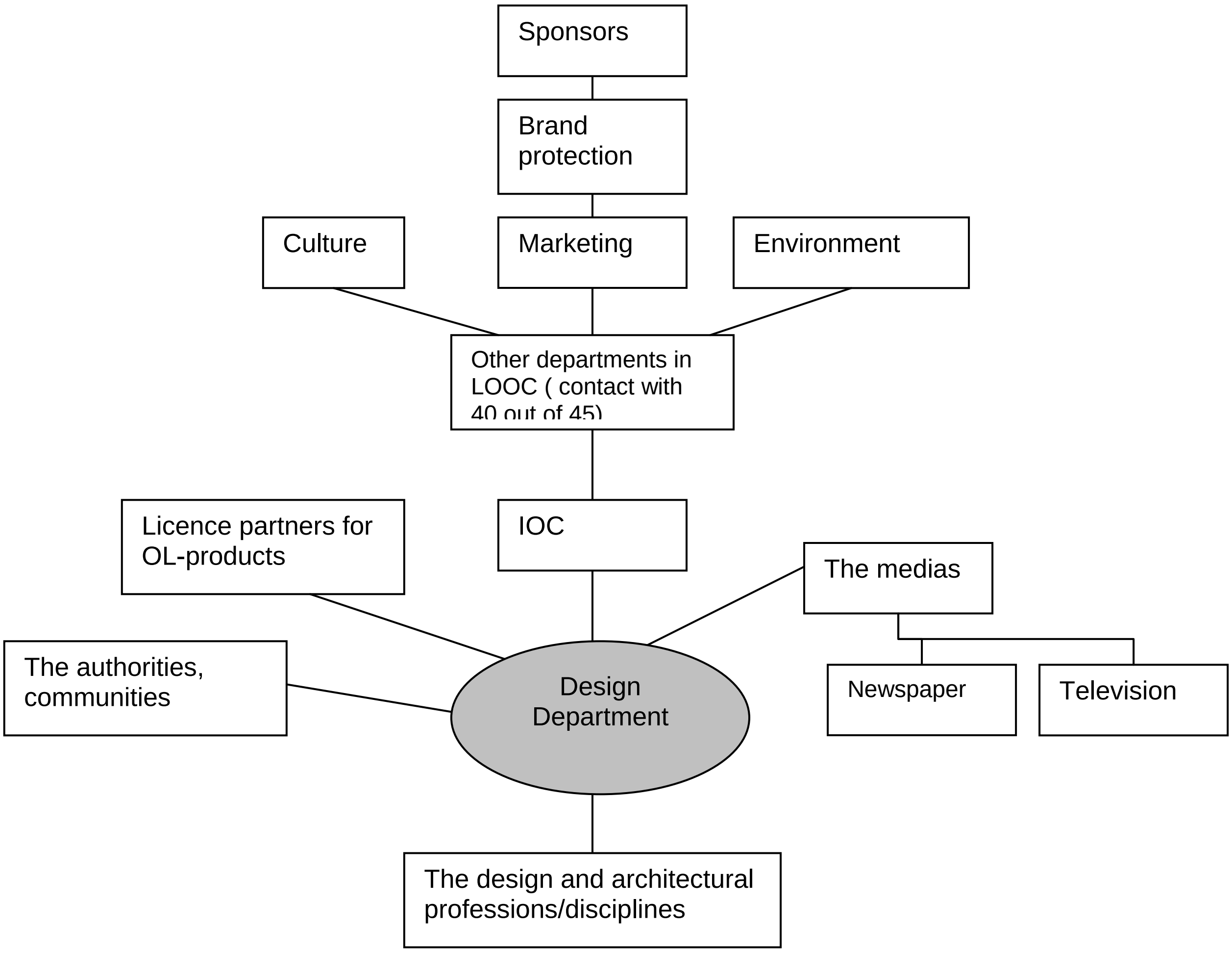


Figure 52 The most important co-partners and professional branches.

The execution of the design program had to be done through co-operation with many different external and internal partners(*Figure 52*).
Considering the other departments in LOOC, the marketing department became a very close partner, where meetings where held twice a week in the most intensive periods lasting for about 6 months. The difficult task for the designers and marketing people was to agree up on almost 40 licensed companies and 800 products (1400 with variations), which had to be integrated in the thinking of the design program.

The department of environment did not have concrete cooperation with the design department, but they did evaluate different decisions in concern of environmental impact.

6.3.5 Design models

The LOOC design department used the *monolithic*, model where all the activities are distinguished by characteristic visual features. This is a strategy in line with the other alternative, which is to create individual brands for each of their products (e.g. for chocolate).
The Olympic Winter Games Lillehammer ‘94 was therefore built as one brand.

The design programme was the steering tool throughout the organisation concerning decisions which would affect the visual identity of the Games (*Figure 53*).

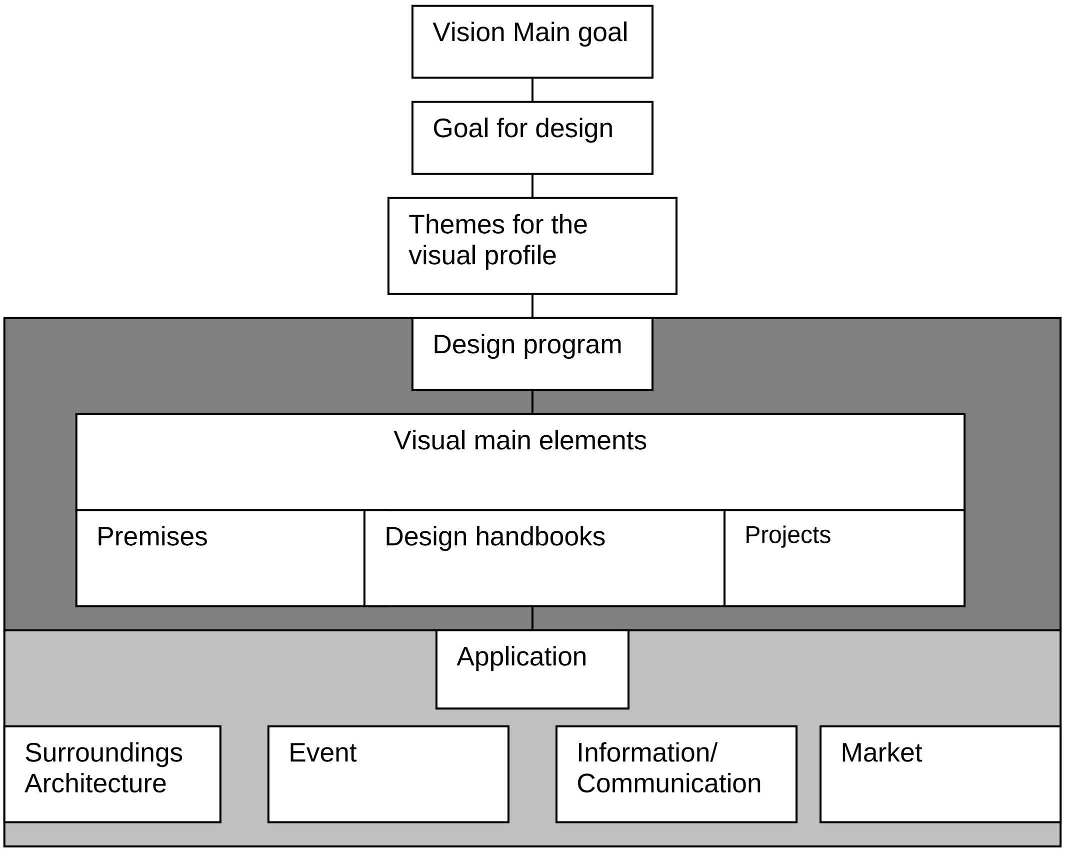


Figure 53 illustrated how the design program would capture most activities and departments in the organisation (Moshus 1994).

In the application of the design program the design department was extremely conscious concerning the equality between partners and themselves. They where inspired by Søren Kierkegaard and his ideas of how to include others and be a driver towards a certain goal.

“If I shall succeed to lead a human being towards a certain goal, I must first find the human where it is and start exactly there.” (initial sentence, p122, Moshus)
Søren Kierkegaard (1813-1855)

6.3.6 The Design Programme

The design programme was designed by Knut Harlem, Reidar Holtskog, Åsmund Sand and Sarah Rosenbaum, (DesignGroup ’94 ANS) all head hunted by Petter Moshus, Head of Design in LOOC.

A Design Programme is describing means systematically used in a long term process.

The Design Programme for Lillehammer’94 had its function in three main areas:

- To promote the Winter Games before, during and after the event.
- To create a holistic atmosphere.
- To guide all product designs and graphic designs for The Olympic Winter Games.

The programme was designed stepwise, whereas the vision was introduced on an overall level and then brought further to more detailed level.

Three themes were given for the Design Programme p. 04 :

- Norway’s distinctive features and national character.
- The closeness that exists between people (“togetherness”).
- The close link between the people and nature.

Each of the three themes had their keywords and further description concerning meaning and intention of the themes.

Goals were also made on the basis of these themes

- Holistic visual profile based on the *Norwegian character and specialities.*
- Create an including event reflected by diversity, happiness and richness(frodighet) within simple frames and with the possibility for second use /reuse.
- Create a "showcase" for Norwegian designs and architecture, environment and culture, and finally Norwegian values, products and services.

The designers should be inspired by the old Greek words from the originally Games; Citus, Altius and Fortius, which basically means breaking/crossing borders (grensesprenging).

The goals were pointing to both functional and expressional criteria. This gave the following keywords for motives and elements: sporty, folklore, historic, ethnic, and geography.

6.3.7 The Design methodology

The vision of the games: " It is intended that the Winter Games in Lillehammer shall be not only a sportsfestival but also a celebration centred upon the summit of human sporting achievement and sound and proven values."
(no.:idrettsfest) (no.:folkefest) (no.:utfoldelse) (no.:ekte verdier)

The organisation choose five such *proven values* as : closeness (no.:nærhet), participation (no.:delaktighet), joy (no.:glede), naturalness (no.: naturlighet) and fair play (!)

These five values were described in detail, concerning how the committee interpretated these values (Design programme p.03)

The design involved

- The basic visual elements for a holistic visual profile presented in the Design programme (see 7.3.8
- Mascot development
- Festival elements, scenography, atmosphere, etc
- Signs and cards, primary plan: Nybro-Bjerch
- Exhibition
- The delivery of The Games, 12.th -27.th of February 1994, 61 competitions, and 1737 sport participants from together 67 nations
- Maintenance during the Games
- The Olympic papers "Hugin" and "Munin"

An important part of the graphical design work consists of the many design handbooks, which were made during the total time period.
The main design handbook remained as one big and the most important book and was only given one additional part in the middle of the planning and design period. Many other more detailed handbooks where made later as they where asked for or seen as necessary.

6.3.8 The Design Handbooks

The Design Handbooks were meant to be used as motivation and as instruction on certain detailing. They included the goal and themes of the Games and became a very important tool for communication or guiding as such.
Guiding was needed for: the volunteers, media, safety, transportation, chauffeurs etc.
Also among people in the staff there was a use for internal focus and guidance on human activities and behaviour.

The product design was defined in two categories. Products for the organising of the Games, and products for sale, souvenirs etc.
Design competition was given for the design of new conference chairs.

The medals where finally designed by the internal design group in LOOC, after having a competition which did not give the accurate result the design management was looking for.

The clothes collection brought a national debate to the media by introducing a modern expression to traditional design patterns. The collection was presenting different outfits for different occasions, but a volunteer hostess and the queen would wear the same clothing at a formal setting. This was manifesting a part of the vision, equality.

Several products where designed and produced externally by companies who applied for an Olympic-licence. They were forced to use the design handbooks, which gave both good and not so good results.
The securing of the quality of all delivered or bought products was not given enough priority because of financial reasons.

6.3.9 The results

The most important results from the design process was the **Official Lillehammer Emblem** (*Illustration 20* a)**,** however, the **pictogram emblems (***Illustration 20* b**)** stood out as the most significant and became the strongest symbols for Lillehammer'94. The pictogram emblems were used for the different sports activities. Cultural activities, environmental issues, "Birkebeiner Lauget" and the "Torch relay" had their own pictograms as well.

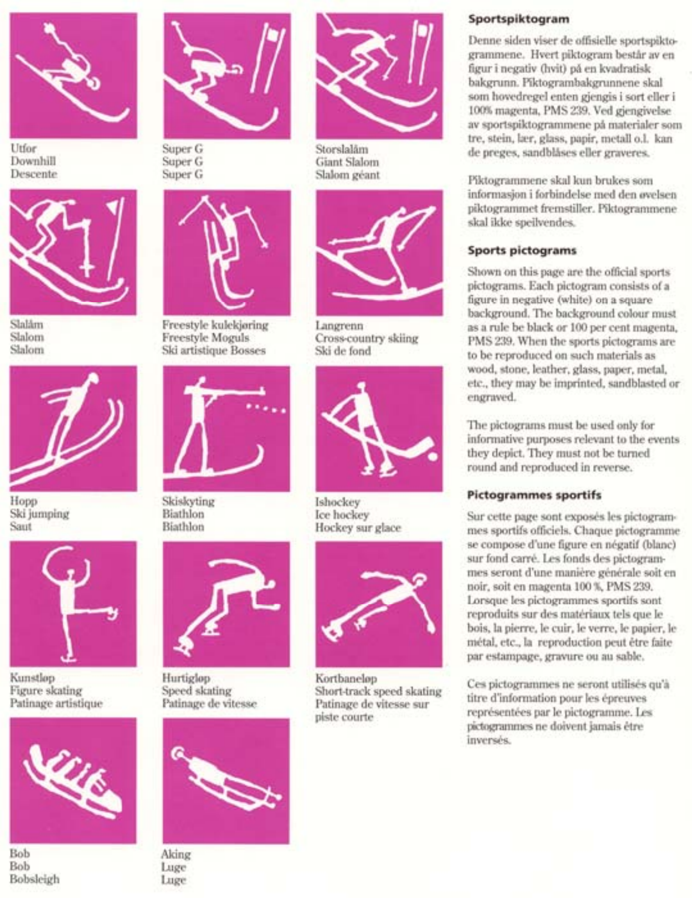
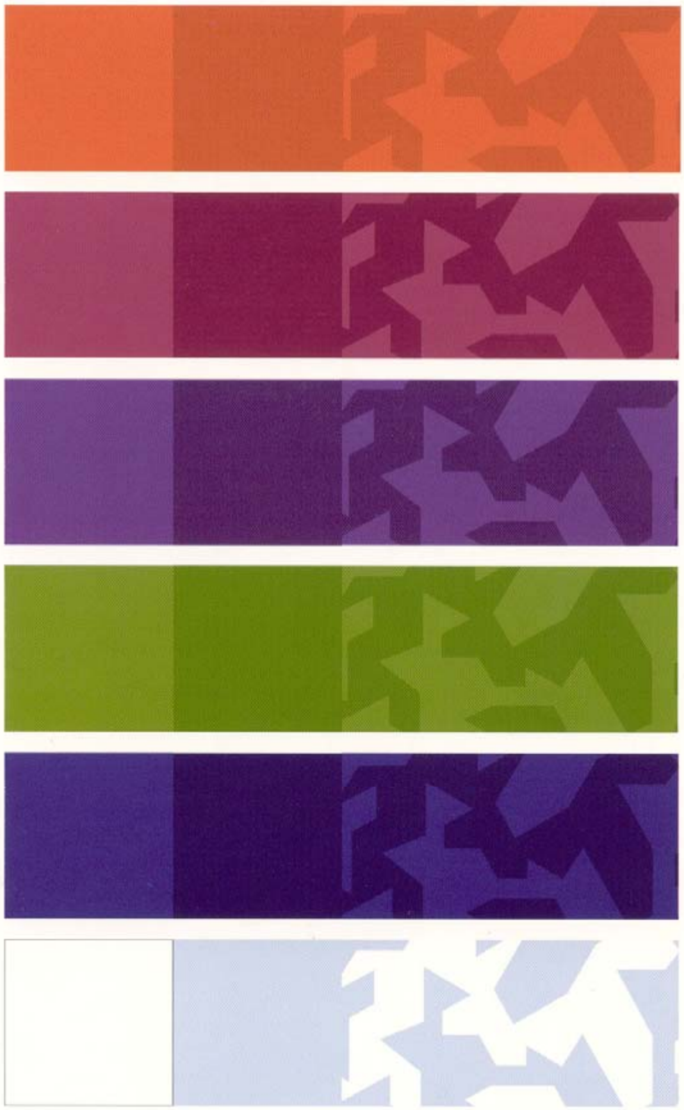


Illustration 20 a and b. a.The Emblem here shown with crystal pattern. b. The pictograms (Design handbook 1991 © Olympia Design Lillehammer A/S)

Then the **"fakkelstaffett",** the LOOC- employees (500) and volunteers (10 000) had their own pictogram.

All these pictograms where new developed for the Lillehammer ‘94 event.

The **snow crystal pattern** (Illustration 21 and Illustration 22)
A special 2D pattern was developed to be used in different settings and in themes of variation.
Colours (Illustration 21) were especially inspired from the project “The Profile Norway”.



Ton i ton

Det er mulig å variere en fargeflate med ton i ton effekt. Dette oppnås ved å blande blå eller sort i fargene som vist i eksemplene til venstre. Dette gjelder kun følgende farger i fargeprogrammet:
PMS 166, 227, 370, 266, 072 og hvit.
Ton i ton effekter kan også oppnås ved bruk av matte og blanke flater.

Two-tone effects

It is possible to vary the coloured area by employing a two-tone effect. This is done by mixing blue or black black with the colours, as shown in the example on the left. This applies only to the following colours in the programme:
PMS 166, 227, 370, 266, 072 and white.
Two-tone effects can also be achieved by using matt and glossy finishes.

Ton sur ton

Il est possible d’apporter des variations à une surface colorée par un effet de ton sur ton. On obtient cet effet en mélangeant du bleu ou noir à la couleur, comme le montre l’exemple de gauche. Ceci ne concerne que les couleurs suivantes:
PMS 166, 227, 370, 266, 072, et blanc.
L’effet de ton sur ton peut aussi être obtenu par l’utilisation de surfaces mates et de surfaces brillantes.

PMS	Process Colours	PMS Two-tone effects	Process Colours Two-tone effects
166	100%Y, 75%M, 5%B	167	100%Y, 75%M, 15%B
227	30%Y, 90%M, 40%C	228	100%M, 50%B
266	80%M, 70%C	268	85%M, 70%C, 30%B
370	100%Y, 20%M, 70%C	364	100%Y, 60%C, 35%B
072	85%M, 100%C	2765	85%M, 100%C, 40%B
White		545	5%M, 20%C

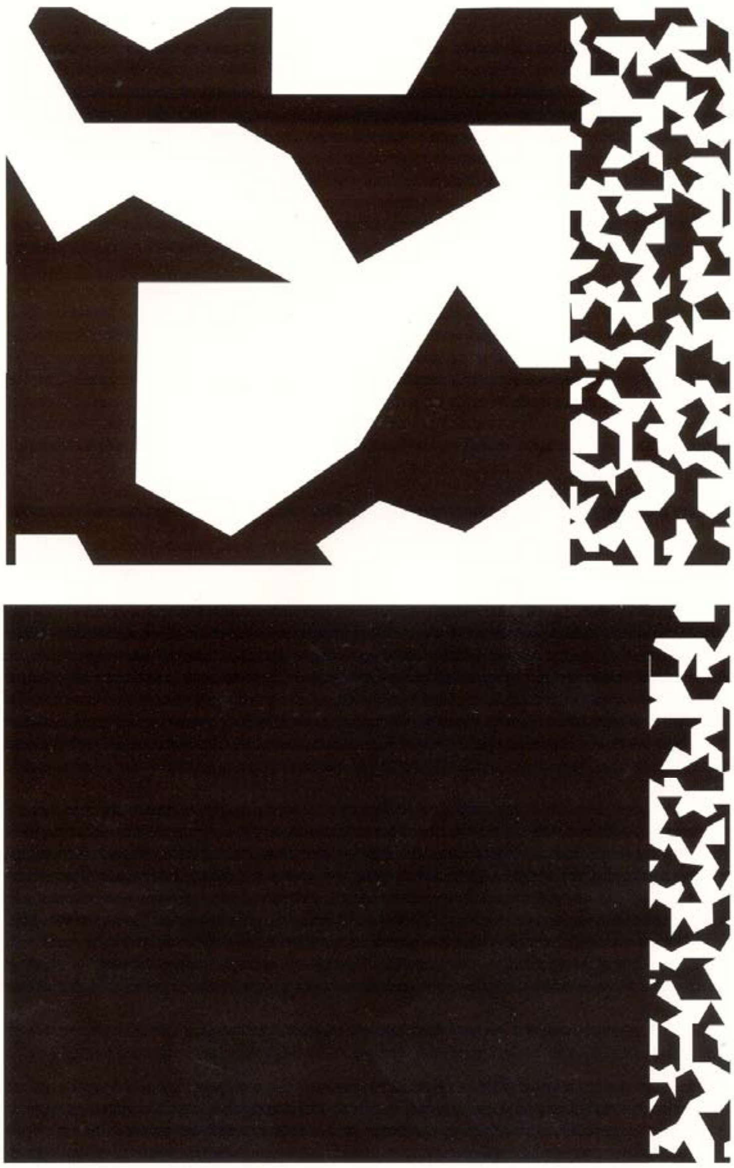
Y= Yellow, M= Magenta, C= Cyan, B= Black

Fargeprosentene i 4-farger er kun veiledende. Trykkresultatet må alltid kontrolleres mot PMS-fargeprøvene.

The percentages in the 4-colour mixtures are intended only as a guide. The printed result must always be checked against the PMS colour swatches.

Le pourcentage des 4 couleurs est donné à titre indicatif seulement. Le résultat de l’impression doit toujours être confronté avec les échantillons de couleurs PMS.

Illustration 21 Some of the colours shown in combination with the snow crystal pattern (Design handbook 1991, © Olympia Design Lillehammer A/S)



Kontraster og flatebehandling

Et viktig stikkord i designprogrammet er kontrast. Store flater skal ikke fylles med mønster bestående av små former som gjentar seg i det uendelige. Skal en stor flate dekkes med mønster, bør mønsteret være så mye forstørret at det oppstår en interessant kontrast mellom enkelt-formene. Skal to størrelser av mønsteret brukes sammen, bør det ene være minst tre ganger større enn det andre.

En mønsterflate bør som regel stå i kontrast til en annen type flate. Den bør danne en interessant kontrast til en ren, hvit eller farget flate, som gjerne er større enn mønsterflaten. Alternativt kan man legge mønsteret ton i ton og la denne rolige flaten skape kontrast til andre elementer som typografi, illustrasjon, foto, emblem o.l. .

Contrasts and pattern sizes

A keyword in the Design Programme is contrast. Large spaces must not be filled with a pattern consisting of small elements that are repeated ad infinitum. If a large area is to be covered with the pattern, the pattern should be enlarged sufficiently to achieve an intriguing contrast between its individual elements. If two sizes of the pattern are to be used in conjunction with one another, one should be at least three times larger than the other.

As a rule, a patterned area should offer a contrast to another type of area. It should form a striking contrast to a pure white or coloured area, preferably one larger than the patterned area. As an alternative, the pattern may be laid two-tone, allowing the more subdued area to form a contrast with other elements, such as typography, illustrations, photographs, emblems, etc.

Contrastes et traitement des surfaces

Le mot contraste est un mot-clé du programme de design. Les surfaces importantes ne doivent pas être couvertes de motifs composés de petites formes se répétant à l'infini. Si une surface importante doit être

Illustration 22 The snow crystal pattern in different dimensions and compositions (Design Handbook 1991, © Olympia Design Lillehammer A/S)

A **typography** (Illustration 23) was chosen. “Country Old Style” for longer descriptions, letters and so forth. “Frutiger” for highlighted messages and headlines.

Illustration 23 The Typography (Design Handbook 1991, © Olympia Design Lillehammer A/S)

The **mascot** (Illustration24**)** discussion resulted into the development of two children's characters, a boy, Håkon and a girl Kristin, who were meant to give the Games this playful and including character. Their name are related to Norwegian history about year 1000 A.C. Their clothes are therefore based on old dressing. However, the children supposed to be carriers of modern attitudes and consciousness.

Illustration 24. The mascots Kristin and Håkon were presented in different activities and expressions (Design Handbook 1991, © Olympia Design Lillehammer A/S)

The use of **materials** were meant to be resource efficient, natural, traditional and based on requirements including security, functionality, ergonomics and environmental friendly in production. This was specifically mentioned in the Design Programme.
The medals and the torch (Illustration 25 and Illustration 26) show how wood, metals, stone and leather are used in the items based on the premises in the Design Programme.

Illustration 25 The medals were designed by the principles of the Design programme. The materials are metals, stone, wood and leather. Design by Ingjerd Hanevold.

© Olympia Design Lillehammer A/S (Moshus 1994)

Illustration 26 “Fakkelstaffetten” , design of the torch Paal J Kahrs Arkitekter AS, based on the directions from the design handbook (source: www.Kahrs.no). © Olympia Design Lillehammer A/S

The architecture and surroundings
The premises where given for surroundings and architecture on three levels. Here the content was more ideological and open for interpretations of different kinds. These premises was described by the a consultancy consisting of Thorsen (interior and industrial designer), Thiis-Evensen (dr.phil. and architect), Moen (landscape architect) and Aarhus (environmental officer), and was added to the Design manual as the last part, section H.
The premises where A) The all over idea (ideology), B) The general C) The local
More specific this meant the A) National and political perspectives and criteria for a OL-event held in Norway B) Concrete consequences for the overall idea C) The possibilities of the concrete placement.

Finally, the creation and success of the Design Programme was depending on

- Tight cooperations
- Ownership and involvement
- Vision
- Totality through details
- Staff of architects and designers
- Continuous improvement

Olympia Design Lillehammer AS, secured the rights for further sales success of license products even after the closing of the Winter Games.

6.3.10 Evaluation of Lillehammer '94

Different professionals were asked to evaluate the design results from the Olympic games at Lillehammer '94, based on their competencies and perspective. The social anthropologist Arne Martin Klausen followed the process in present and wrote a book *Winter Olympic Games 1994 and the Cultural Dimension* (Klausen 1994) focusing on the cultural aspects and meaning of this event for the Norwegians. Lillehammer '94 won the Scandinavian design award 1994.

Design Researcher Birgit Helene Jevnaker et.al did a more thourougly study and evaluation on the design process in OL'94, including interviews, video recording and several visits to relevant people and sites. The design manager, Petter Moshus has also presented a self evaluation from the design department in LOOC.
Jens Bernsen et al (in Moshus 1994) from Danish Design Centre have the following conclusions in his evaluation:

The organization:
It was an effort among involved participants in april 1990, which resulted in a design initiative in LOOC. This emerged to an expanded design department and a Design programme for Lillehammer '94. An unusual strong leadership has given profit to the total project.

Petter Moshus describes in the self evaluation that it took much time and effort to create understanding in the internal organization for the necessity of establishing a total responsibility for the physical and aesthetic planning. He points out that the design section maybe gave too much priority to the internal networking in contrary to the environmental department which worked with the community, municipal departments and the county as administrative unit. Moshus defined the work procedure, process wise driven as "in spite of " rather than "because of".
The learning from the use of early design, was that this should not have been introduced without a planned program, including a theme and vision for the project.

Jevnaker, however, is underlining the crucial aspect of the work done by the design department building support and cooperation across the borders between the departments in the organization of LOOC, and on levels in the project organization, in order to succeed.

The design programme:
Bernsen is giving critical remarks to some of the details in the design programme which may be mostly negative in concern of directions given to the producers of license product. Special qualities are a brief consisting of specially clear criteria concerning the image, a consequently following up in the design programme in terms of these criteria, that the program with success contains three "fifth" identity elements which are the cave paintings, snow crystals and mascots (the macro graphical identification)

It is extraordinary that a design programme developed by 4 different graphic designers has achieved this holistic expression. The design director, however, was skeptic about the starting point, which was founded in two elements (the logo and mascot) designed as ad hoc solutions for different previous Olympic applications. This can become a lump on the leg in the further process.

C: Implementation:
The implementation has given a clear identification of the event, which again has marked Norway as a design –nation. The licensing, however, gave some problems to the profile. The super graphical use of cave paintings as inspiration has been spectacular.
Bernsen points out that design is both process and result and that is was crucial for Lillehammer’94 that the design initiative came early and that the design department came in close relation to the executives in LOOC.

The pre-project promotes the priorities and the long lines. It does not interfere with solutions. The report is a design brief, this is a criteria specification for the designers, who are intended to develop the design programme for Lillehammer’94. It was easily read and was inspiring and presented a clear picture of the functions of a design programme.
Bernsen, however, is evaluating it as a risk that 4 design offices were involved in the process towards a total concept.

The design programme was the platform for more handbooks specified for the different tasks in the games. This was seen as a plus by Bernsen (Moshus 1994). It was also important that the basic elements were designed already three years before the games took place. The design manual was a good working tool in spite of some weaknesses. Bernsen continues with his positive remark that it was seen favorable that the program was describing through the means of both words and pictures the goal which was set in terms of associations and a Norwegian image. He would prefer this even more highlighted. The design programme should have included an own section for the licensee. Many companies found it problematic to use the design programme on their products.

Birgit Helene Jevnaker et al (Moshus 1994) is pointing out the importance of revealing the design process in order of transferring the experiences from Lillehammer ’94 to new design tasks of larger dimension. She mentions that accomplishments within visionary and administrative design management are necessary to succeed. Further, a superior direction and close following up was important.

Petter Moshus is discussing his own view on design and defines the design for Lillehammer ’94 closer to art than the market place. He points to R.H.Hayes (1990) who gives design four roles, being: profitable, differentiating, communicating and integrator of different disciplines. Moshus is adding the aspects as functionality, consumers’ needs, expectations, desires and taste.
Expressions in direction of art are often measured by acknowledgment and quality of experience, while production and marketing activities are often measured by quantity and profit. Moshus concludes that design is placed in between.

Jevnaker is on the other hand suggesting a connection between the long initial idea and analytical phase in the design project with the commercial benefits that the redesigned licensed products achieved in mature markets.

The design director is, however, admitting that LOOC lost some of the control when such a large number of users of the design manual, including licensee, needed guidance. The crystals and pictograms started to live their own life.

Jevnaker is pointing out some characteristics with the design process.
The design management was accomplished through a participating and mobilizing attitude. To create partners for design promotion was a special move in this process. The design management has focused on planning, experience and the social aspects. Birgit H. Jevnaker is also mentioning the support from the design consultancies to internally create a common framework for designing, as another special characteristics for Lillehammer ’94.

Jevnaker is concluding with three important implications from the Lillehammer ‘94’s design initiative:

- To head hunt and pull together design resources: Tailor made teams comprehending the activity/organization
- Competent leaders for the process: Common design direction
- Leader's and employee's valuation of design can be developed in practice: Social and communicative abilities are important.

6.4 Reference project: DSB (The Danish Public Railroads) design program and change of profile

The Danish Public Railroads' company, DSB, has been in transformation the last 7 years. DSB has been in charge of the public infrastructure in Denmark, including buses, ferries and trains. The switch towards competition with private initiatives on the market for transportation, forced DSB to a narrower focus. Trains and the services in connection with the train journey is now the concern of the company. DSB wanted to create a new profile identity and show its customers that they had become something new and different. From being a technology based organisation they wanted to become a service minded business. They where shifting from old values to new values.

DSB was based on the values of
- Reliabiliy
- Environment
- Tradition

The new values became
- Keep it simple
- Committed
- Value adding
- Effective
- Responsible

The design director, Pia Bech Mathiesen (architect) was part of the creation of the new values and the new vision for the company in cooperation with the CEO, Chief Executive Officer.
The new values and the new vision are demanding a new design program. This design program is translating the new values into design visions by the designers and architects in the design department of DSB. Design is used as a corporate management tool in DSB. This is expressed e.g. in the organisation structure. The design director is placed directly under the CEO. For cultural change in the organisation, adapting the new values and visions, the human resource director, the director of organisation management and planning and the design director are now been given the task to cooperate on this process.

The new corporate identity is based on a new :
- Logo
- Colours
- Typography
- Architectural policy
- Design vision

The design vision:
- It shall be easy to go by train
- It shall be safe to go by train
- Good trains for all passengers
- A seat for all passengers

This has resulted for instance in train stations where glass is the main material in the shelters and walls. The atmosphere is light and transparent.

Tickets are going to be sold in a new concept called "kort & godt" (tickets & sweets, but is also a Scandinavian saying meaning "short and good") where tickets, sweets and coffee is sold. Here DSB

will need special employees who can both answer questions concerning the train service and sell newspapers and other kiosk products. DSB is also expecting the purchase of tickets on the internet to reach 50% of the total sale by just a few years.
The concept “kort & godt” has a visual profile, which is harmonising the new design programme of DSB. The design department is also working on scenario building and future concepts e.g. card systems for ticket purchasing and integrated services in their stations, which very often are located in the middle of the cities and towns and therefore invite for central access.

Business and societal responsibility
DSB is forced to think business and understands in a way this that their identity must be clear and include all type of passengers and routes in the country. The profile is not giving priority only to the most travelled routes e.g. from Århus to Copenhagen. A user survey is grouping their passengers into 5 different categories of different needs and user situations. This information has become very valuable to the company and is seen as one of their strengths in competition with others on the transportation market. The train passengers shall be able to combine the use of different transportation means, there are parking places near the stations and bikes can be transported on the train. An inclusive perspective is also capturing older passengers (who is a large user group of DSB) and handicapped customers.

DSB has turned from being a business with “read numbers” numbers to become a business with 1,2 billion Dkr profit in 2002 (http://www.dsb.dk/english/dsb_international/m_bottom.htm#5).
For the coming years they will offer their services further on the international market. This requires an even stronger identity.

6.5 Reflections

6.5.1 System design depends on co-operation based on motivating and clear communication

The total design process became an expanding activity in LOOC, and the result was depending on support from all the different divisions in the organizations. Some of the divisions became close partners (such as marketing and media) to the design section. The project evolved from the few people who initially designed the visual profile, to the extensive work to motivate the entire organization. Further the project needed acceptance by the Norwegian people, and then finally reached the world through mass-media.

Communication based on the preferences of the recipients was seen as one of the most important tools to motivate external and internal stakeholders of the visual design programme for Lillehammer ’94.To complete a design programme and to manage major changes in a company (DSB) requires co-operations driven by strong individual motivation not only from the leadership but also from the team participants and supporting stakeholders.

The factor 10 pilot-study (chapter 5) can proliferate to many new specific projects, however it seems from the case-study that the projects must have a stronger established roots in the respective businesses, or be initated by a person with the mandate to create an expanding development activity in the company. The design concepts should be clear before they are promoted for evaluation, further discussions and concrete detailing. The vision can be a internal reminder of where the project is leading.

6.5. The design function is a strategic concern

In order to use design as a strategic tool for total development, the design function was upgraded to a higher level in the Lillehammer Olympic Organisation Committee. As for the reference project, Dansih Railroad Company, the Head of Design had a direct communication and co-operation link to the CEO in the company. This was seen as necessary in order to transform the company vision to the product and system vision and manifest the new values in solutions which were serving their customers, the passengers.

The written reports, books, Design programme and Manual from Lillehammer’94 are not revealing the details in the human processes, how the vision, themes and strategies were actually created.The specific design methodologies used by the Design Group ANS' 94 , or how this group was established are other issues the material is not covering.

The next chapter presents the essence from deep interviews, which give deeper and more detailed information concerning the indivdial experiences from project participants in the Lillehammer '94 case as well as the factor 10 pilot study.

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7.0 Interview Results

One aim for the thesis is to find a methodological framework for Radical design projects. This indicates a connection between theory and practice. To support practice the framework must be related to the human processes and the individual apprehension of good and less good tools and approaches in the design work. Further, the participants in the pilot-study and the Olympic design team might have important opinions, which are not channeled to the research group or in written reports, but are expressed in an (anonymous) interview. The interviews with different participants from the same project (four persons from the pilot-study, two from Lillehammer '94) project also a wider totality and diversity to the written material and researcher's personal experiences related to the studies.
To interview eight people, each of them for about one and a half hour, is a privilege. The situation of asking questions and listening to new perspectives broadened gave a deeper insight to the business world compared to the world of researchers. The interviews are filling gaps in the written stories in chapter 5, Pilot-study, and chapter 6, Case study, and especially concerning important details in the human processes. Two deep interviews were made with colleagues at the Department of Product Design Engineering. These interviews revealed related issues to other research within design, but also to practice.

This thesis is providing a birds-eye perspective of both the pilot study and the case study and is analyzing the processes in order to discuss a factor 10 framework for design and development. The interview results are coded and presented in this purpose, however, each of the three interview groups where interviewed based on different interview guides (see Appendix VII) suited for the respondents' different background. The deep-interview methodology and coding is described in detail in chapter 4.9. The professional title of the interview respondents from the pilot were Researcher (working in a research foundation), Project engineer (in company), Project manager, R&D (in company) and Manager Juice and Beverage Products (in company). The two interview respondents from Lillehammer '94 where both graphic designers. They had the position as Head of Design in LOOC and co-ordinator of the Design group ANS'94, which designed the Design Programme and Manual for the Olympic Winter Games at Lillehammer'94.

7.1 Aims and objectives related to the interviews[6]

7.1.1 Post pilot-project Interviews

(Chapter 5 is describing the pilot study: pre and main project.)
In Autumn 2003, four of the participants from the pilot-study where respondents in deep interviews prepared and done by the PhD candidate.Three of the respondents where participants in the main project. One interview respondent was from the pre project and had only initially taken part in the main project, but also attended the final seminar, summer 2003.

[6] See chapter 4. 9 for description of the research approach, which includes the procedure for the deep interviews.

The objective of the deep interviews was based on three motives:

- How the participants experienced the process in terms of project structure, goal and achievement, and time spent in comparison with own ambitions on behalf of representing a company.
- How the participants would distinguish this process from the more traditional design work and environmental tasks in their company.
- How the industry can implement this type of working procedures in parallel or in synergy with daily duties and development

The aim was:

- To evaluate and compare the weight of the time spent on different focus in the project vs the outcome and expectations. This is important in the terms of motivation and further development of the methodology considering setting goals
- To grow the characteristics of the methodology to become more clear for future communication and introduction of the new methodology/framework
- To reveal what are the main barriers for implementation today and what are the positive drivers

7.1.2 Case study related Interviews

(The chapter 7 is describing the case study.)
Two interviews were with respondents from the design process of the Olympic Winter Games, Lillehammer '94. The Head of Design and the coordinator of the Design Group ANS'94 were key-participants and were therefore chosen.

The objectives of these interviews were:

- How the vision for the Games was created
- What where the main drivers for cooperation and communication between the stakeholders in the complex design project.

The aim was

- To understand the mechanisms for creating the common vision in this case study.
- To reveal the driving forces which mobilise a number of stakeholders towards the common vision.

Further in chapter 9, these procedures and mechanisms will be discussed concerning the possibility of transferring them to factor 10 design projects. This knowledge is important in the construction of a new design framework for factor 10 development, including long term visions and various number of stakeholders for system and product design.

7.1.3 "Reality check" Interviews

Two deep interviews were made to evaluate the temperature within other design research areas, in this case, aesthetics and man-machine interaction, to evaluate the tendencies and parallels in comparison to the factor 10 experiments.

The objective of these deep interviews were based on one motive to find out:

- What are the possibilities of implementing the factor 10- design methodology in Norwegian companies today?
- What already existing procedures are useful to broad perspective thinking in product design processes?

The aim:

- The theory and pilot study should lead to development of tools which are realistic to implement in some type of design processes in industry today. The deep interviews should map some of the activity within other type of design activities.

The results from the "reality-check" interviews are presented in chapter 9 in connection to the discussions and the main study of the research material.

7.2 The structure of the coding and presentation of results

Coding of interviews

All interviews are transferred to text as prcicly as possible from taperecordings. Every answer and question in the transcription was then coded in terms of content with a macro-cluster and a microcluster. The interviews are coded with the same grid for the interviews executed for the pilot-study, case study and reality checks (see chapter 4.7.2). The four macro-clusters give a main structure to the analyses and are defined as *Framework, Project Management, Human Processes* and *New Methodology*. The coding is reflecting the issues that were common to all the deep interviews, and with the aim of revealing experiences which are of high importance in design (for sustainability) in networks.

The main content within the different clusters from each interview was then translated to English and placed in connection with the other interviews in one text (see Appendix IX). Finally, the following sections are presenting the material as small summarizes of the results and direct qotaions which are found of high relevance to the specific cluster but also the larger totatilty.

7.3 Results from deep interviews

7.3.1 Framework

The terminology on this macro-cluster might be confusing in parallel to the aim of the thesis which is to develop a *methodological framework.* However, in the interview context “Framework” includes the discussion of networking, how the projects were based on networks of different participants in the project (design) team as well as in the phase of production and realization of the new concepts (case-study). Further this macro-cluster pinpoints the drivers in the projects, the common interests among the participants, and finally the choice of starting point for the design task.

Micro-cluster	
Networking	*Pilot study: Factor 10* The framework for factor 10 projects is seen as the networking of business and how their individual strategies are fitting into these co-operations. An indicator for how the business strategies fit into the network may be the possibility for the different participators to integrate this type of project into their daily work. All the business participators were challenged by their daily tasks or lack of acceptance from leadership to participate in the factor 10 main project. ***"The businesses should become more committed to the network, executives, who are involved in future strategy development would be important participants. To actually implement the concepts, these people have to become engaged. If only environmental people are involved it is often hard because they do not have direct communication link to the leadership in the company."*** B3 Project Engineer *Olympic Winter Games, Lillehammer '94* Networking was initiated on all levels in the design process, and the design manager was very conscious concerning the need of networking both internal and external in terms of the organisation. The design team was loyal to the businesses which supported the winter games, the money came from these stakeholders and therefore they had their natural interest in the project[7]. Also, these companies had participated in Lillehammer before and none of the locals had, at least not on this level. It was however obvious that there where internal conflicts of interests between the design section and the marketing department in LOOC who was responsible for the wellbeing of the sponsors. (C2 Head of Design) Networking was initiated on several levels and the design task itself was executed in a network of independent design bureaus. The coordinator of the Designgroup '94 ANS was very pleased considering the personal climate in the team and the final results of their work. ***"This type of work gives you insight from new perspectives and input which you did not think of before, it is very enriching. The Lillehammer project would not have resulted the way it did if a single bureau should do the work by itself. The four firms all together gave a fine input to the entire work."*** C1 Coordinator of the Designgroup '94 ANS
Drivers	*Pilot study: Factor 10* The drivers and starting point for the participants varied from personal motivation to professional interest. One of the respondents meant this project was part of an important type of research, which would be relevant to all industry in some years ahead. He believed this was necessary for his own company too, although his own company was not totally on his side in this priority. To be evaluated and receive honor by NGOs was also mentioned as an important driver. A business respondent felt it was hard to find strong drivers in her company since their activity was not of the "dirty" kind that really needed to be cleaned up and changed in total. One respondent was convinced that a priority today on sustainable issues would bring

[7] In the Olympic Games as such there is no commercial promotion at all on the arenas for the sport events. This is unique for the Olympic tradition in modern times.

	advantages to the participating companies concerning future competition criteria. Innovation and new long term marketing perspectives were seen as strong professional drivers to attend this type of project by the participants. The environmental issues were understood as inspiration and catalysts for these issues. *Olympic Winter Games, Lillehammer '94* Head of Design did also have the feeling of Samaranch exposing LOOC for some pressure concerning brand building and its importance for a total presentation of the winter games. ***"The design function was pulled some levels up in the hierarchy in LOOC, however the CEO was always worried that design was increasing the total expenses. The budget was a framework."*** C2 Head of Design The budget was setting some limits, but the design manager was able to increase the design stab and expand the budget in some degree through hard work in communicating the functions of design and the design programme. ***"It is not typical for Norwegian companies such as SAS, to change the entire style of the company over night, this is part of the uniqueness for Lillehammer '94; they managed to complete the process. That is great."*** C1 Coordinator of the Designgroup '94 ANS Another driving force for the project was the short time available. It was a tough progress demanded on parts of the work. (C1 Coordinator of the Designgroup '94 ANS) When the design team was in place, the marketing directors and sponsors who had paid a lot of money, where setting the premises. They probably had in their contracts, right to have something for use within a certain time. (C2 Head of Design)
Common interests, starting point and values	*Pilot study: Factor 10* Consumer focus and user- orientation was not mentioned by any of the respondents in the first place as an interesting starting point for a networking process, although they all meant this area was of high importance. One of the respondents pointed out that increase of energy and resource efficiency is of major importance to most production companies whatsoever the environmental profile might be, however, another respondent experienced that the environmental issues are not seen as starting point for new innovation and strategies. *Olympic Winter Games, Lillehammer '94* The visual profile was very important in terms of international broadcasting on television. The graphic design was an important tool in reflecting what the Norwegian population relate to Lillehammer and Norway. For this reason it was important to do the work as good as possible. Both respondents are mentioning the TV-camera and television as important focus in terms of priorities and design strategies in the project. The environmental issue was not a driver or starting point in any degree in this project. Nor do the respondents evaluate this issue as a strong driver in today's projects. ***"It was probably some protests from NGOs against the big event arranged in small Lillehammer, followed by pressure from IOC; and not from the***

	***government, that made LOOC give priority to some (environmental) internal projects, then the government took initiative and some "rescue projects" where executed*."** C2 Head of Design IOC has, however, intensified both the design and the environmental criteria for later hosts for the Olympic Games. This is where the environmental effort maybe had the highest influence, rather than specific at Olympic Winter Games, Lillehammer '94.

7.3.2 Project management

The questions concerning project management included the micro-clusters: ownership and steering, planning; long and short term, the role of the designer and other participants, what methods were chosen and how the coordination and symbioses between research and design was tackled.

Micro-cluster	
Ownership and planning	*Pilot study: Factor 10* The focus of the project seem to be closely related to key participants in the project, however these actors were also the "engine" in the project and developed a lot of material in between the seminars. It was seen as a draw back by all of the respondents that the business participators were not dedicated to specific work between the sessions, the pressure, however, from daily tasks was an obstacle for placing the factor 10 project higher on the priority list by the business participants. ***"The interval between the working seminars was too long. The participants lost the thread to some extent. Another possibility was that the seminars could have been longer, 3-4 days instead of 2 days."*** B1 Researcher Three out of the four respondents thought that the project had a too long duration and favorable could have been proceeded more intensely in some direction, either with shorter intervals or longer working seminars. One respondent , however, underlined the importance to have several days working sessions so that one could really dive into the work with good focus (B2 Project Manager, R&D) *Olympic Winter Games* Initially only one person was assigned for the design job in Lillehammer '94. It was also a discussion of where the designer should be located. The design function was first set to the information department, then to the Culture department, then again back to Information. The design manager sees this as symptomatic for design. It is something in between. His first assignment was to redesign the mascot, which was originally designed by a Mexican designer for the Olympic application in the late 80's. The unofficial pre-project suggested for LOOC to develop a design programme in order to achieve a holistic visual profile for the games. The single assigned designer managed to increase the amount of designers for this task, and lead the process in finding the external design team. The Head of design chose the different designers for the first design team, by their character. One firm was already chosen for the project, they were solid,

	systematic and had been in the business for a long time. Another designer was seen with his name on some interesting posters for the Oslo cathedral, he was young and single freelance graphic designer. Further, the Head of Design chose another larger bureau and designer who had worked on “Norgesprofilen” (Eng.: “The Norway Profile Project”), which was a project which the government expected Lillehammer ’94 to build on. The last designer should be a woman since the others where all men, and so the design manager found a “girl- bureau”, which had done interesting things, and a woman from this bureau participated in the group. (C2 Head of Design) ***“My perhaps most clever move was to decide that we should compose a group to develop the design program, not necessarily to carry it out, but to develop it. The group was consisting of four different designers from four different design bureaus.”*** C2 Head of Design Head of Design introduced later a fifth designer, who became the graphic responsible designer for LOOC (Ashley Both). She was in charge of the detailing in the design program. The entire concept and the different elements, however, were developed by the four initial designers, each representing a large towards small design bureau.
Designer’s role	*Olympic Winter Games* ***“An ordinary designer’s role is not just to make the colour blue if the client asks for it? It is somehow a way to see it in a larger perspective too, and be a type of opponent or have other eyes and be able to communicate with the client, not just do as he is asked. The Lillehammer ’94 has probably been more driven by design or designers than by the service department or the marketing department.”*** C2 Head of Design The designers worked very independently with the entire design programme, it was more on the detailing that the discussions where closer to LOOC’s own designers. The holistic programme and the ideas behind, however, where open tasks for the designers. It was, however, not more open and independent in terms of how the respondent usually try to work.(C1 Coordinator of the Designgroup ‘94 ANS) The design process in the Designgroup ’94 ANS was coordinated by the representative from Engen & Harlem. In general, though, the team coordinator points to the necessity of having someone on the director level, for example a marketing director, to take part in the ownership of the project. When the design programme was formally accepted by LOOC, LOOC hired an internal graphic designer to follow the detailing process together with Head of Design in LOOC. All the meetings where then documented in a summary where all the decisions and ideas where described for the next meeting. This was a good steering tool. (C1 Coordinator of the Designgroup ‘94 ANS)
Methodology	*Pilot study: Factor 10* ***“To combine the factor 10 project with short term goals is hard, but we have introduced the thinking into our innovative projects. This is challenging the team both in their thinking and use of their existing skills.”*** B2 Project Manager, R&D One respondent suggested that the companies should have people employed on regular basis to work on scenarios and future strategies. Another respondent imagined that their marketing department probably already were working with similar methods, such as future scenarios, but from another perspective.

	"The invited participants were all environmental interested people, this was natural in a start project, but later on, if you want to include the social and economical parts, people with these competencies should perhaps be included." B3 Project Engineer *Olympic Winter Games* Head of Design did interfere with all issues they thought where important, where there was not already a designer involved. The methodology was based on experience and intuition, further they were both tactic and strategic when they looked around. A part of this was to create understanding and to work on the premises of the recipient, to create a good communication. Both for positive and critical response. The internal designers in LOOC did some of the requests from other departments, but did also place jobs with other external designers who had learned the design program. This also provided new interpretations of the design program, which gave dynamics to the expression. Head of Design and others wrote a lot of documents internal in the system. Goal and milestones, how these goals were achieved, reporting the results, and goals for the economy and progress in percent for the different milestones. All these management systems where used by all departments of LOOC. Head of design understands this as originally used in the petroleum industry and off shore, introduced to LOOC by the executives with carriers in that business. (C2 Head of Design)

7.3.3 Human processes

The macro cluster of human processes is divided in three microclusters: Communication – as a strategy in the project work as such, personal motivation and the experience of ownership (informal) among the participants in the project, and working methods that were seen as special.

Micro-cluster	
Communication –strategy in project	*Pilot study: Factor 10* Communication, motivation and working methods were related and major topics considering human processes were pointed out as the most important experience in the main project. One respondent saw the human process as most crucial to succeed in this type of projects but doubted that all type of people actually would be able to participate in such open processes. The participants could not hide behind a mask of formality if the building of future scenarios should become lively and honest. The same respondent regarded the participation itself as the most important and saw a challenge in distributing the knowledge and experiences fostered by the main project. All participants saw the need of a communication tool for further distribution of the results and project process, vision and background drivers. A "easy-selling" brochure was suggested to promote this type of projects both internal in the participating companies, and for external purposes. *Olympic Winter Games, Lillehammer '94* When the main concept was designed, every internal department in LOOC got a presentation of how the design programmes could look like. The Design department and the Designgroup '94 ANS presented all the basic elements, from the logo and further on, -for about 10 departments. It was very well received by all departments.(C1 Coordinator of the Designgroup 94 ANS) The Head of Design managed to bring in the minister of culture, almost as an alibi,

	to announce the new mascots for the winter games. There were a lot of critics towards the spending of money for the Olympics the first years of planning. However, when the design team presented the design program and the pictograms – this is it – it became a success. Dagbladet (Norwegian large tabloid newspaper) wrote in the leader "Now we have complained enough concerning OL, but here is something to be happy about." So the design department came in a positive spiral. (C2 Head of Design) The positive feedback in the media made it easier to work internal in the organization. Everyone wanted to be on such a winning-team (C2 Head of Design) ***"The President of the Olympic Winter Games, Gerhard Heiberg, would ask me to make the design presentation in the beginning of a difficult meeting with outsiders, to bring people in a good mood. Design can be used for so many things."*** C2 Head of Design The coordinator of the Designgroup 94 ANS had the understanding of the Head of Design spending much time communicating the design tasks, the vision and themes internal in LOOC. He communicated the thoughts and ideas, which were underlying the design programme, and that it (the design programme) should be followed, that was the most important. He spent a lot of time on this, and the Designgroup '94 ANS prepared the material for promotion. There were, however, a lot of things that the Design Department could not control at all. On the other hand, they had provided a toolbox, which was available. (C1 Coordinator of the Designgroup 94 ANS) Head of Design had made a survey internal in LOOC, mapping the need of design assistance; what they where going to make and so on. The work "took off", when they understood more about design in the different units; that all what they made and where doing, everything that had a shape, had an effect of how the organisation was interpretated externally, and that this was a part of the design. (C2 Head of Design)
Motivation – ownership, emotional	*Pilot study: Factor 10* ***"The experience of coming more personal in contact with the other team members promoted a personal commitment to deliver higher quality contributions."*** B1 Researcher *Olympic Winter Games, Lillehammer '94* The design manager made a list of the most important stakeholders. Then he came to Øyer County to make them motivated, however, he had to use a different approach of communication towards Coca-Cola. He used a basic presentation, including scenarios which where made initially by the Designgroup 94 ANS. They had made lots of "dummies"[8] of how things could look like, and sketches. Two slide series that he has shown thousands of times. Then the dummies where exchanged with real things and in the end there were only real things. The management system for the entire organisation with written defined goals, was a must for everyone in LOOC. These type of written documents, however, would not help the design manager to persuade Øyer County or the Coca-Cola Company to join his team if he just presented these documents. His approach was somehow a way to speak to the heart for common goals, and winning together.

[8] "Dummies" are simulations or simple models of products, brochures etc. "Dummies" are usually not functioning prototypes but only show superficially how the final product may look like. In product design "mock-up" is a similar expression for models on this early stage in the design-process.

	Petter Rønningen[9] had an introduction course for all new employees, the way real companies have. And then the design manger was allowed to attend and give a mini presentation; "this is the design program", the reason for its characteristics and how it became like that. In LOOC they where 700 employees and 10 000 volunteers whom the design manager represented for, to give them ownership to the design program and knowledge about its history and purpose. This way the volunteers could tell others about the design programme, both to visitors and their own surroundings. (C2 Head of Design) They had their needs as designers, one of the goals was to make architecture and design that Norway could be proud of, this included more personal goals which the rest of the organisation committee was not so interested in. Once the human resource director came and said to the design manager: "You are strange you designers, you are almost religious", in comparison to the other 300 professions that where represented in the organisation. (C2 Head of Design) The Designgroup 94 ANS and the coordinator experienced early that this was an exciting task. Initially the results met very good response also internal in the design field. This happens very rarely that almost the entire field supports the results of a project. (C1 Coordinator of the Designgroup 94 ANS)
Working methods	*Pilot study: Factor 10* The working process consisting of unusual setting was experienced as sustainable in it self, giving energy to the participants although they worked intensively. ***"The characteristic of the project was the informal atmosphere, which made all participants equal partners in the discussion. The working method, sitting in a cottage, was promoting all participants to get involved and destroyed typical hierarchic structures."*** B1 Researcher Olympic Winter Games, Lillehammer '94 ***"For four different design burros to function well in this type of cooperation, the most important was to be open for thoughts and ideas. I experienced it this way, it was a sketching process where one step at a time was taken and results fell in place."*** C1 Coordinator of the Designgroup 94 ANS In general, the team leader works open with his clients in the sketching phase, to discuss and evaluate all ideas and directions, corresponding to the scope of the project. All ideas are exposed on the walls in the meeting room. In this process, the client becomes owner of the decisions and achieves a deeper understanding of the results. The pre-project, however, shall have provided criteria and premises for an interesting platform for what the main project shall look for in these open discussions. To have your drawings put on the wall and maybe torn down if it is not good enough, can be a tough process for some designers. It is a part of the teamwork though and this is how the respondent is used to work. In the Designgroup 94 ANS, this working method was a new experience to two of the participants but no problem. (C1 Coordinator of the Designgroup 94 ANS) In the design team the discussions went back and forth before decisions where made, there was a sort of democratic process, and the group seemed to have corresponding feelings concerning the final decisions. There where some intense discussions, but all on a professional level in terms of certain solutions. (C1 Coordinator of the Designgroup

[9] Petter Rønningen was the vice- chairman in LOOC.

	94 ANS) It was a lot of intuition, they were a good team and they where tactic, it can probably be described as different methods. To the design manager there where basal things like communicating on the premises of the recipient, to find win-win situations, and try to understand, and to understand others, but at the same time be clear in concern of what the goals are and be faithful to these. It was new for them all, no one had done something as big as the Olympic Winter Games before. (C2 Head of Design) The Head of Design and his designers were sitting close at location to the logistics and construction people. This was not planned on forehand but was very useful. The initial plan included only one single designer. (C2Head of Design)

7.3.4 New methodology

The macro-cluster “New methodology” is referring to the aim of the thesis, and contains microclusters that refer to the steps and elements in the factot 10 pilot study and additional steps which is seen as relevant in the new methodological framework. The microclusters are: Scope definition, Analyses, Scenario building, Vision, Strategy, Idea generation, Concept evaluation and finally Further development and detailing (how to take the new concepts further in the design process).

Micro-cluster	
Scope definition	*Pilot study: Factor 10* The project was seen as unpredictable to some degree by all of the interviewed parties, however they all had different type of expectations and ambitions. The participants had unlike views concerning the scope of the project, which seem to be connected to the professional background of the different participants. One of the researchers with analytical background defined the project as a mapping of today's situation and future possibilities, to analyze the bases for new solutions, although he also would have expected a closer connection to new solution development. Other respondents with engineering background expected the project to become more focused on future solutions and more doing than analyzing, however, all respondents expressed their respect for different scopes and motivation integrated in the project. Other professional backgrounds were also mentioned as important priorities for later projects,both marketing people, social scientists and economists. This would be necessary for both the analyses and the development of new concepts followed by realization. *Olympic Winter Games, Lillehammer '94* ***"This was just as much about the soul and identity and the total concept. Visualisation of a will, that entire Norway was occupied by. We shall have the winter games, and everybody knows it is about people who go skiing, but there was so much more surrounding it. Being a host and compress and show things to the people abroad. Show a self portrait and maybe redefine the own self portrait."*** C2 Head of Design The goals should be achieved and they should preferably be quantifiable so they can be controlled afterwards if they are achieved or not. **The operational goal was to make a holistic visual profile for Lillehammer '94.** The design manager gave high priority to television and areas where the television –camera was pointing at, showing pictures. What the team leader characterised as part of the most important success criteria is the common strategy and philosophy of what you want to achieve. If it is two-dimensional, architecture or material use, there is a need for a common platform which is important to build initially. This was done by many inputs from different expertise. The results are found in the Design programme and main handbook. The development of the Design Programme was a two-dimensional project, however, promoting the premises for design handbooks concerning for example festival elements (which are both two and three- dimensional) done by Kjetil Moe, responsible for the architecutural profile. One of the respondents points to his private practice and says that the design brief must be extraordinary good and detailed if a pre-project is not seen as necessary
Analyses	*Pilot study: Factor 10* One of the respondents felt that the data-collection was hard to complete and was challenging concerning the big differences in quality and accuracy for the different drinking products. A rough analysis was, however, a reasonable result in this type of project. The respondent meant that businesses, who were not attending the project were not so interested in contributing with their data. This was understandable, and a familiar problem to the respondent. The participants with research background were not questioning the process of analyzing, while the two respondents with product development focus meant it would be sufficient with an approximate picture

	of today, if the scope is to reach a level of factor 10 in the future. In other words, they understood the analyses as too detailed, but respected that other participants in the project had genuine interest in these aspects. However, one of the respondents found the amount of time and detailing on the data collection and analyses was disproportionate to the rest of the project. The analyses were inspiring to the same respondent though, in terms of finding future solutions, based on the knowledge of today's weaknesses in the systems. *Olympic Winter Games, Lillehammer '94* LOOC applied for the Olympic games to Lillehammer already in 1982. The team leader for the design programme Lillehammer '94 was involved already at this stage to design a logo representing Lillehammer. If they did not succeed in the battle for the winter games, the symbol should at least mark Lillehammer to the map. This symbol or logo (variations of the emblem) was inspired by the northern light, but as a symbol it could express movements of different types in sports. The same designer continued the work on this logo for Lillehammer'94, before the leading design manager was positioned in LOOC. TV is the most important medium for the Olympics. Engen & Harlem had designed two symbols and then there was the third which was simplified and fitted for television. Experience from other visual profile projects was supporting the process in understanding what was needed. The winter games in Albertville and other Olympic games where also sources for information. (C1 Coordinator of the Designgroup '94 ANS) A pre-project had been done on the governmental level (UD), which was called "Spor" (Eng.: Track). It focused on a profile for Norway in terms of tourism and international promotion of Norway. This project was a basis for a design programme which perhaps was not very successful; the pre project however, was good. It said something about colour and design management that was interesting so it was included as a part of the information material for Lilllehammer '94. The new design team was in shortage of time. The respondent set up a specification list based on the reports from the pre project for Lillehammer '94 and other mentioned material . "What do we need? We need background surfaces, some abstract patterns, some pictograms…", because all other Olympics had this, then the design manager had seen what was done in Calgary and other places including what was to be read in literature. They could not use the visual profile from UD ("The Norwegian profile") both because of the readability in choice of typography and further because it all had to be unique in order to be protected and reserved for exclusive use. (C2 Head of Design) There was a large number of logistic people and the entire analyses of the logistics in connection to the arenas was surely highly developed. The design team however, was not central in this, perhaps some of the architects where though. (C2 Head of Design)
Scenario building	*Pilot study: Factor 10* All of the respondents enjoyed the scenario building personally. It was a relief to the three business respondents, being allowed to think in a longer term and wider perspective than usual. All respondents saw this work useful, but where more doubtful how to integrate these techniques in their daily work. The business participants, however, expressed high interest in being able to do so. One of the respondents suggested a closer relation to the participating companies, concerning development of the future scenarios. Business strategies, threats and possibilities, wishes and visions in the companies could be ingredients that where taken into account in the scenario building.

	Olympic Winter Games, Lillehammer '94 The team had made scenarios, to increase the financial budget. They said that if the weather turns to the same as in February 1993, wet, grey and cloudy, and there was no financial priority to the down town area, no banners or flags, that would not be nice. The arenas was of first priority, followed by the close up cameras, and the entrances to the arenas. The design manager was not able to give priority to downtown of Lillehammer. However, these worst case scenarios where made. Then they managed to make sponsors support two banners without the sponsor name and then a third one with a small logo. (C2 Head of Design)
Vision	*Pilot study: Factor 1* ***"It feels more right and important to have a vision in this type of project, a large project involving many stakeholders and which has something to do with the future. The vision should be a driver in the project towards the goal, and can say something about this little project in a larger totality."*** B1 Researcher The vision was discussed as an underlying, far ahead goal by the respondents. It seemed that the participants had different view concerning the mission and content of the vision. One respondent felt that the vision could have been written short and clearly in the beginning of the project, as a part of a reminder for why the group was gathered and what the task factor 10 was about. The same respondent meant it was important that the vision was defined by the team itself in the beginning of the project so it didn't feel forced upon anyone. Two of the respondents mentioned that traditional projects did not have a stated vision, but goals and specifications. To introduce a vision in the factor 10 project felt natural though. One respondent meant that the vision in this main project was not as important because all the participants should have a good grip of what this was all about. On the other hand, if the project was to include new participants who where unfamiliar to the factor 10 concept, then a defined vision would be extremely important. *Olympic Winter Games, Lillehammer '94* ***"It was many stakeholders who contributed to the vision, it was a process. This is how this type of projects proceeds, many people are involved and it is always hard to tell who did what on certain times. The design director, however, had the capability of pulling it together.*** " C1 Coordinator of the Designgroup '94 ANS Head of Design worked with the vision and goal, but so did the main organisation, but they took their time. Before they were finished, the design manager had come up with his own themes for the design programme; "The closeness that exists between people ", "The close link between the people and nature "… - They included for instance "let's be inspired by nature, not copying it." ***"Then the organisation came later with their vision, but luckily it fit with the themes, so when you see them afterwards, it looks like they stick together."*** C2 Head of Design The vision and themes where defined before the design team started the design process. It was done in the right order. The design team leader cannot recall at what point exactly the themes where in place, however, they where of high importance for the design work and later presentation. They gave some key words to remember all the time, such as "closeness" (No: nærhet). (C1 Coordinator of the Designgroup '94 ANS)

	"For Lillehammer'94, the vision and the framework that was defined there were very important. What defines the material choices and the spirit for how this should be; it was important for everyone to pull in the same direction." C1 Coordinator of the Designgroup '94 ANS

Strategy	*Pilot study: Factor 10* ***"What is not sufficiently developed is the means to free the businesses and researchers from existing patterns and support cooperation in new structures."*** B2 Project Manager, R&D Two of the respondents found that the development of strategies for further idea generation was coloured by scarcity of time and therefore represented a lack of co-operation in the network on this procedure. One of the respondent disliked how the strategies very much were placed back in segregated blocks, focusing on smaller areas rather than based on the co-operation which the project was giving an opportunity for. The same respondent recommended for further factor 10 activity a higher priority at this stage in the project. He saw a great challenge in finding tools for smoother co-operation and in finding untraditional strategies, not only focusing on the motivation, which was already represented. Another respondent found the focus on water and related strategies of high interest and an issue his company easily could find relevant. As pointed out by more of the respondents, the existing infrastructures are representing tremendous amount of barriers when new ideas are challenging these. Two of the respondents were de-motivated to some degree when they understood that the most important issues for sustainable development within the drinking product systems were outside of their daily reach today. ***"It is also a paradox in the work that the strategy, which can lead the project closer to its vision, is the strategy which is the hardest for the companies to execute."*** B1 Researcher *Olympic Winter Games, Lillehammer '94* The design team leader and his team had provided a tool box for further design for the winter games. What was made here should be style-setting and predict ways of doing things; it should work as inspiration for the people taking over when the design team had finished their job with the design manual. The design team created a form but at the same time did not dictate how things ought to be designed. They received good feedback of having sheets for inspiration in the manual. There are not so many "must not" signs but rather more for inspiration. On the other hand, it was not allowed to use other things. C1 Coordinator of the Designgroup '94 ANS The design manager said to the license businesses that now they should think differently, this time it was the Olympics and flags and moose was not what the people wanted. A change of attitude was necessary but some of the companies where tough to convince. This was a risk to take though; if the design programme and including elements had not been successful in concern of license products, the design manager would have been responsible. They did however sell ten times more than stipulated and the financial profit on license products was higher than the profit from ticket sales. (C2 Head of Design) The tex-industry was the biggest barrier, saying they would not be able to sell anything of this. The colour palette the designers presented was out of fashion considering the trends that was seen coming for 1994. LOOC said, however, that they where the ones who defined the trend for -94, and the team leader imagined that the tex-industry never had sold especially designed fabric as they did for the Olympics. The Olymic committee in Albertville warned LOOC because of their rather bad experiences with license products. In Norway it became a profit of another world. (C1 Coordinator of the Designgroup '94 ANS)

	The environmental issues where addressed in symbolic value more than real ecological value. It was not that many tonnes material for use, so it was more the symbol of connection with nature and not to pollute and so on. The mascot children possessed a caring attitude and promoted good patterns, being nice and honest. The environmental impact was not a part of the discussion when the design programme was developed. Protests and demonstrations from NGOs forced the LOOC to take action, and then they made some projects internal. Following up, the government initiated some rescue projects. On the other hand, this was then "sold" to IOC, who sharpened their environmental premises for later Olympics. (C2 Head of Design)
Idea generation	*Pilot study: Factor 10* ***"The project risk is unproportionally high if one tries to innovate all aspects of a business all at ones. Compromises need to be made related to" Factor 10"development in some area to ensure the success of the next generation products and services."*** B2 Project Manager, R&D This step in the methodology was not including the participants but mainly executed by students in they thesis work and by some sketches and idea collection by the PhD candidate. Three of the respondents had previous experience from product development projects. One of the respondents had introduced the factor 10 thinking concrete in an innovation project in his company. This was an issue he introduced the respondent undertook even before his participation in this pilot study. He had experienced this type of thinking as an extremely efficient tool to get loose from the old conventions and - "how shall we really do this different and better?" Factor 10 idea generation is different in the way that it is more complex than just embracing single solutions, was the reflection of another respondent. ***"The thinking starts by tearing the solutions of today apart, finding the basis functions and work from there. There is a resistance though in some disciplines to break the traditional rules of material usage. By introducing a vision, good motivation, and leave people with time to make some reflections and calculations, team members start to think differently."*** B2 Project Manager, R&D *Olympic Winter Games, Lillehammer '94* The design team leader arranged an **individual** brain storming in the beginning of the idea generation. The designers draw all their thoughts and ideas of how the basic elements should look like, without interruption. Then they put all the ideas on the wall in the meeting room and they started to evaluate the thoughts. The initial idea of pictograms from Sarah was among the drawings in this very early phase. So they started with all these individual thoughts and ideas of what the visual design could consist. This individual process lead to some ideas that stood out, and where brought further. Every participant where then given some tasks to think about and work on until the next meeting. This open discussion where all the ideas were presented on the wall, and then chosen or excluded, was very good. (C1 Coordinator of the Designgroup '94 ANS) The use of the northern light as inspiration for 1982 generated further development of the symbol. It was natural phenomenon that belonged to the north and is visible in the winter. Many things came up, the design team discussed the darkness in the winter and how it would be right to bring in light and fire. The fire (no: ild) can be used both indoor and out door. A pattern was developed which was build on the shape of flames. (C1 Coordinator of the Designgroup '94 ANS)
Concept evaluation	*Pilot study: Factor 10*

	One of the business respondents had long time experience in evaluating ideas within his company, using the SWOT- analyses and a newly introduced gateway system, organising and developing ideas on a systematic basis. This phase in the pilot study was not methodologically integrated, but discussed in the last chapter mainly written by the project leader. *Olympic Winter Games, Lillehammer '94* ***"Visions, goals and values are words, and then expression is something else. There is no single solution if the expression should be joy or connectedness; we have all our picture of that so it can not be measured. The team should be on the track but there was no need to go back and look things up in the folder.***" C2 Head of Design There was no concrete measurement of the ideas specific in any way, it was more a feeling for what they all where looking for. However, it was clear after the presentation at Lillehammer (red.: the departments at LOOC) that both LOOC and the design team were satisfied concerning the expression they had found, which was answering the expectations and showed no inconsistence with the vision and themes. The design team was excited about their own ideas, for example the pictograms, but where not sure about the reactions from for example the sports people. There was, however, no one who reacted negatively on the simple and organic pictograms and how the different sport activities was represented. (C1 Coordinator of the Designgroup '94 ANS) It was more convenient to explain the rejections to all the positive initiatives from all over the country when there were the visions and material perspectives to refere to. People wanted unnumbered products introduced at the winter games. It was made a special handbook for the license companies to follow. In concern of the licensee, it was important to have a common procedure with the marketing department to evaluate and approve the license products. The companies attended workshops to become familiar with the design programme. The companies came and presented their ideas and products. If it was not accepted, they always got directions for further work. (C2 Head of Design) The design manager tried to steer the use of the design program but also to avoid misuse, and to motivate both internal and external. (C2 Head of Design)
Further development and detailing	*Pilot study: Factor 10* This is often the starting point in traditional development and design projects. An existing product or system is focus for redesign. The detailing is critical for the total concept. ***"The factor 10 projects are in the starting point placed on a higher level than traditional development projects, so you will not result in a concrete product. In traditional projects your scope is to develop a finished product which you have in your hand when the project is over."*** B3 Project Engineer *Olympic Winter Games, Lillehammer '94* The design team had made the design programme, then the work with the design hand book was supposed to be exposed to competition. The initial design team got the job, if not it would have been a scandal. (C2 Head of Design) Then began a big job, to specify how the final symbol and emblem should look like. Further the design manual should explain also how things should be done, put together with the other elements with typography and such. All this had to be

	detailed. How this should look like when it was placed on different backgrounds and so on. For arena design it was important to have “Lillehammer ’94” quite large, you have to think of a football field. It was the design team that defined the criteria and how everything should be used. What was important was to imagine all type of scenarios, where this should be used and in what context and so on. Two of the design team members had major experience with these type of projects (no: flerprofilering), so they had an overview, but at the same time they looked for example to Spain (red.: Barcelona). This was, however, more to confirm what they already knew. Later there was made more handbooks for example one book for development and design of festival elements. The team leader, Coordinator of the Designgroup ‘94 ANS, was working partly as a consultant giving advice to further design tasks such as designing signs. Åsmund Sand was one of the designers in the Design Group’94 ANS who worked further with the specific development. All this work was then based on the design manual, which represented a lot of tools. (C1 Coordinator of the Designgroup ‘94 ANS) The design department tried to specialize internal when the department increased in numbers of people. Some handled the sponsors and some the cultural events and so on. (C2 Head of Design) The design manager, Head of Design, felt that the environmental solutions where banal humoristic, like the trays and cutlery made out of cornstarch. LOOC did not manage to make systems for controlling the bioplastic trays to go into composting, so it all ended in the garbage with everything else. The symbol effect was the most important, but then there was the traffic solution. The Lillehammer region was closed, busses and trains where set up and no private cars where allowed in the closed area. This was a great sign, which also made it pleasant for people to be at Lillehammer, too. We have traditions for travelling public when we attend for example “The Holmenkoll Sunday” (Ski events in Oslo). It is part of the Norwegian mentality to enjoy being a “clump” and not single individualists on these events, and you create this common atmosphere a little before you enter the tribune.(C2 Head of Design)

7.3.5 Future possibilities and challenges

The interview questions concerning *Future possibilities and challenges* were related to the macro-cluster *Framework* in the interview coding, but is actually intervening with all the different aspects to the project.

Micro-cluster	
Further development (future possible practise)	*Pilot study: Factor 10* All the respondents expressed enthusiasm for the factor 10 thinking and believed it had important aspects to add for future sustainable projects. There are still many obstacles for these type of projects to become a priority in today's industry. In addition, new capabilities concerning openness and different thinking is demanded and may be difficult to achieve on higher levels in the companies. ***"If you are not able to break up the roles existing between stakeholders in industry today, then you will probably not be able to do more than small incremental changes."*** B2 Project Manager, R&D To reach the CEOs in the companies the communication of the factor 10 approach and selling in projects should be very clear and include the question "what happens to the company if we do not attend this project?" ***"The networking and thinking as in factor 10 must be more concrete in connection with the business task; to become interesting in the future. The good argumentations for new solutions and discussion of contexts (scenarios) can be a driver."*** B4 Manager Juice and Beverage Products *Olympic Winter Games, Lillehammer '94* The design programme set new standards, and now IOC have stated that every city who is hosting the Olympics shall provide for a design conference expressing how important design is in the Olympic context, and brand building. Then there shall be a competition for every Olymic emblem and the whole as such. The respondent has been to several places after Lillehammer, to hold lectures and later on to sit in juries for these competitions. Both the issues of design and environmental criteria have been formal implemented in IOC's consciousness. (C2 Head of Design) Networking has always been done in this field, and should continue. The design team leader believes in design activities of this kind, however, most people(businesses) still, in Norway, do not understand what it (design) is all about. (C1 Coordinator of the Designgroup '94 ANS)

7.4 Short summary of key findings

7.4.1 The pilot-study

Framework

- It seems clear that the main barrier for this type of projects in businesses today, is the loose or lack of connection with the daily work in the company.

- Driver: the innovative character of the Factor 10 project was probably the strongest driver for implementation of these types of projects in today's businesses. The wide perspective towards different markets and future consumer behaviour was also mentioned as a positive driver.

Human processes

- The working methods "off-site" created an informal athmosphere which promoted stronger commitment and motivation for high professional performance by the participants in the project team.

- There is a need to perform both individual work combined with discussions and work in team process. Lack of individual tasks is slowing down the “learning curve” and the project progress.

New methodology:

- Scope :There seem to be some disappointment in the total results, being too general and with no specific product and system development initiated in the team work. The scope for the project was inexact.

- Scenario building and working method:The interviews revealed a general excitement about the project. All participants found the scenario building as a rich experience. This was the step in the process, which was given most working hours in plenum, and done in “off-site” locations.

- Scenariobuilding and development strategies: The results from the scenarios seem to be accepted by all participants as sketches of possible futures, whereas the further use was unclear. It was suggested by one of the respondts to spend more time on this critical step in the work from scenarios to vision and strategies.

- Vision: the vision should be a reminder of the larger connection for the specific project and remind the participants of the reason for why the project is done. The vision gave signals of a long term focus in the project.

Future development and improvements.

- The factor 10 design approach should become more precise and explicit in scope and goals.

7.4.2 The Lillehammer’94 Case study

Framework:

- Networking: The Head of design was most satisfied with his decision to combine 4 different design bureaus in one design team for the initial work which set the premises for the visual profile of Lillehammer ’94.
- Driver: Limited time and high prestige project were important drivers to the progress.

Project management

- Professional experience, creativity, flexibility and strategic use of communication tools is seen as crucial.

Human processes

- Communication through visual methods had a strong effect internal in LOOC to achieve acceptance for new design concepts, and external to motivate partners and other stakeholders.
- LOOC involved all employees in the design philosophy to build a personal ownership and provoke commitment to the organization vision and the Design programme and manual.

New methodology

- Design methodology is a part of the participants thinking, rather than a step by step instruction found in books.

- Vision and themes: In spite of an unclear process where the vision and themes were created by “separated” individuals, the further work seem to be driven by good teams and clear communication channels.

- Concept Evaluation: To evaluation of non-material values, such as joy, manifested in a material solution, can not be measured, however, there may be created a consensus in the team if the project is on the right track or not.

Future development and improvements.

- Networking and transdiciplinary design teams is a tool for future development, however it demands knowledge and a conscious use of the design function in a company.

The results from the “reality” check interviews (Group A) and the material from this chapter will be further evaluated and studied in the next chapter, chapter 8.

References

Interview guides and samples of the transcription and translation of interviews:
Appendix VII, VIII and IX

8.0 Observations and main study

This chapter presents the findings in previous chapters, connected to the theory, in response to the research questions. This chapter will make the material as transparent as possible. Chapter 9 will then present the next step in the process of discussing a framework for the initial phases of a factor 10 design, or rather Radical design projects.

The theory and empirical data from the factor 10 concept reveal a dominant technological and material focus. The environmental challenges are, however, not far behind, and are related to human activity and the satisfaction of human needs, most of which are of a non-material nature. Max-Neef presents the satisfiers as having four phases or states: being, having, doing and interacting. In the commercialized society, business initiatives are made to satisfy as many of these needs and states as possible, although some needs cannot be really satisfied by a physical product or commercialized service, such as the need for affection and the need for freedom. Commercialized satisfiers for these fundamental needs are most likely pseudo-satisfiers. Design for sustainability should result in solutions which give synergic satisfiers (Max-Neef 1992). This means they open for more needs to be satisfied in one solution, while not inhibiting the satisfaction of other needs.The first set of research questions is also asking how the long term consequences and goals can give directions to the short term present activity. A new design methodology for this purpose must also give a warning to the design team when the new ideas are on the wrong track, not supporting a sustainable development. An evaluation of early concepts and their qualitative content of sustainable principles on product, system and global level is necessary. This is studied in relation to the second set of research questions.

8.1 Focus of research questions and the subsequent research study

The first research question in this thesis concerns the initial starting point for the design of these types of solution, which with respect to the factor 10 concept aim for synergic satisfiers for fundamental needs. The sustainability measures are the consequences of human activity in a long-term perspective, 30 years or more in the future. The next research question therefore asks how the satisfaction of fundamental needs can be transferred to the long-term perspective, for example being described in scenarios, and then be integrated in the design process to guide the first step of design activity taken today (short-term steps)in a company or organization. However, sustainability is also dependent on at least three parameters: the ecological, social and economic performance on the global and local scale. This thesis also emphasizes the spiritual and cultural aspects of a sustainable society and life. These parameters must be integrated in the design process to give direction and content to the new ideas. The process in defining the sustainable parameters for the new specific solution should also contribute to the choice of parameters for measuring the qualitative performance of the new ideas. The quantitative analyses need to be complemented with an evaluation of the principle nature of and the non-material values that are chosen for the new solution.

The Lillehammer ’94 case study was chosen to examine the design methodology used in such a large project, which involved a vision leading to a design profile that embraced many products, services and communication. The factor 10 pilot study did not reach the process of bringing the overarching new ideas to the “drawing table” and realization into physical products, services and systems in the near future. To fill this crucial gap, the case-study was chosen not with specific focus on sustainability, but rather on the demanding process of going from vision to real solutions of commercial interest.

8.2 Data analysis, validity and reliability

The validity of the collected material and the systematization and analyses that followed depends on the choice of steps taken in the total process and the circumstances which have influenced these decisions. However, research is also about thoroughness in the execution of the methodology, and revealing one's own tracks and presence in the research. This is related to reliability (Robson 2002). As discussed in Chapter 4, the epistemology of phenomenology is about *evolving the understanding* of the world, not neglecting but rather being “dependent” on the subject, namely the researcher as a human being and as a part of the process of research itself. This demands a strong awareness of one's own bias. However, the chosen research methodology should strongly reduce any threat to the validity of the study.

Triangulation is a strategy widely used to reduce the threat to validity. Triangulation involves the use of different sources or methods for data collection to reveal uncertainties in the material (Robson 2002). This thesis employs more than one method for data collection both “horizontally” and “vertically” in the research process. The pilot study is referred to and presented in light of the reports, interviews of participants, and in part the researcher's own participation. The philosophical argument in Chapter 2 is based on three theoretical literature sources and discussions. While this may be the most tenuous part of the thesis, it can be followed and commented on by other researchers. The case study from the Lillehammer Olympic Winter Games is explored through written material and reports, the original design programme and manual, and through interviews with key persons. The case study represents a complementary design methodology in comparison to the pilot study, placing emphasis on the practical approach and a completed project with respect to system design and holistic design solutions.

The structure of this thesis and the detailed explanation of the research approaches help to trace the steps in the research. The interviews have been transcribed as precisely as possible and have been checked by the respondents before making any analyses and drawing any conclusions.

The following sections of this chapter will present the findings in the described structure presented in (*Table 21*).

Research focus in research questions	**Keywords in research**	**Empirical material**	**Discussed in section:**
Q1 How can product and system concepts be designed to promote factor 10 development?			
Q1a Starting point: Functions Experiences	Starting point Prime movers Networking Ownership System design	Pilot study Case study (interviews)	8.3 8.5.2
Q1b Long-term perspective	Future scenario Strategic design management	Pilot study Case study (interviews)	8.4
Q1b Short-term steps	Project management and planning	Pilot study Case study	85

	Design methodology	(interviews)	
Q1b Setting of a company/organization	Realization of concepts/ Implementation of methodology Holistic thinking Human processes	Pilot study Case study (interviews)	8.6
Q2 How can design concepts be evaluated in the early phases of the design process, when it comes to their ability to contribute to a future development in a factor 10 direction?			
Q2a Defining qualitative sustainable principles, guidelines and criteria	Ethics: Worldview Value of nature Human experience Material flows: Ecological patterns	Philosophical argumentation	8.7
Q2b Entering conscious sets of values directing the choice of ideas	Vision Themes	Philosophical argumentation Pilot study Case study	8.8
Q2b Evaluating the early concepts	Existing evaluation procedures	Philosophical argumentation Pilot study (interviews) Case study (interviews)	8.9

Table 21 The table provides an overview of the research questions, their focus, relevant research material and in which section each is discussed.

8.3 Starting point for factor 10 design projects

Q1 How can product and system concepts be designed to promote factor 10 development?

The research questions are based on the assertions described in Chapters 2, 3 and 4, which are based on the theory that reveals how ecological and human problems are closely related. Ecological problems cannot be discussed exclusively but must include human activity and needs. Technological needs satisfiers are a major cause of today's ecological challenges. The main focus of this thesis is to explore the connection between the starting point of a development process and the possibilities of reaching a system design based on sustainable principles. The first research question is therefore:

> **Q1a** Can connected functions and experiences serving the end-user be the starting point of a co-operation between main stakeholders, rather than the products themselves?

Factor 10 development should occur in the societies which are consuming unsustainable amounts and types of energy and material resources per capita. Future products and systems should promote this development. However, in its very nature the factor 10 concept presents the Western world's need for new solutions, and as described, based on a radical reduction in material and energy consumption. For other parts of the world, new solutions and different types of development are also required, however, with focus on improvements in living standards and in many cases with an increase in material and energy consumption (factor x, x<1) (see Figure 5, Chapter 1.4.1). Nevertheless, this should be based on human needs and sustainable values and principles. *Radical design thinking* is here introduced as the term involving both the factor 10 concept and the human focus on qualitative values.

It might therefore be questioned if the traditional focus on material solutions can be the starting point for a design process of this kind. If the goal is to decrease the use of materials or at least keep this as efficient as possible, it might be important to focus on the actual needs causing a demand for material products. It is important to distinguish between the starting point, the focus of a project and the prime movers (drivers). The people in different positions in a manufacturing company will have different interests in the prime movers and likewise in the starting point of a project. The prime movers, however, are important when initiating a development project but also when giving high priority to completing a project. Nonetheless, the starting point and initial focus will determine the steps in the process and the final result.

8.3.1 Starting point

Technological functions are familiar starting points for engineers and developers in Norwegian companies. Researchers within environmental fields who tend to favour quantitative measurement also focus on the material properties. User experiences or attention to end-user needs, as a starting point for development or research, appear to be less popular.

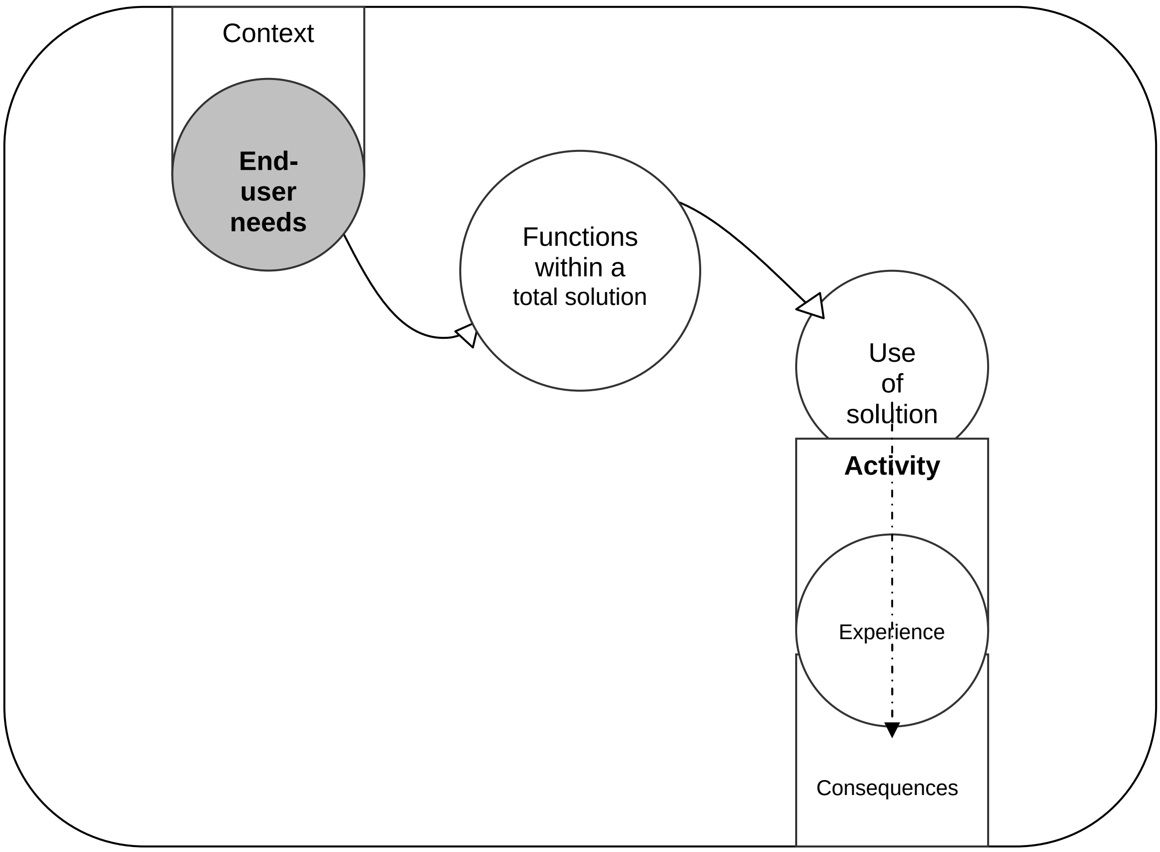

Figure 54 User needs should be explored in the proper context and answered in functions within a total solution for satisfying sustainable user activity and experiences.

If the activity and needs are the starting point of the task definition in the factor 10 design projects, the next task is to define the appropriate functions and experience as part of the emerging vision and subsequent strategies for the new solution (Figure 54). This type of starting point might lead to unexpected solutions where previous material elements and the appearance change totally, or the functions are served by human assistance or natural settings and the material product vanishes.

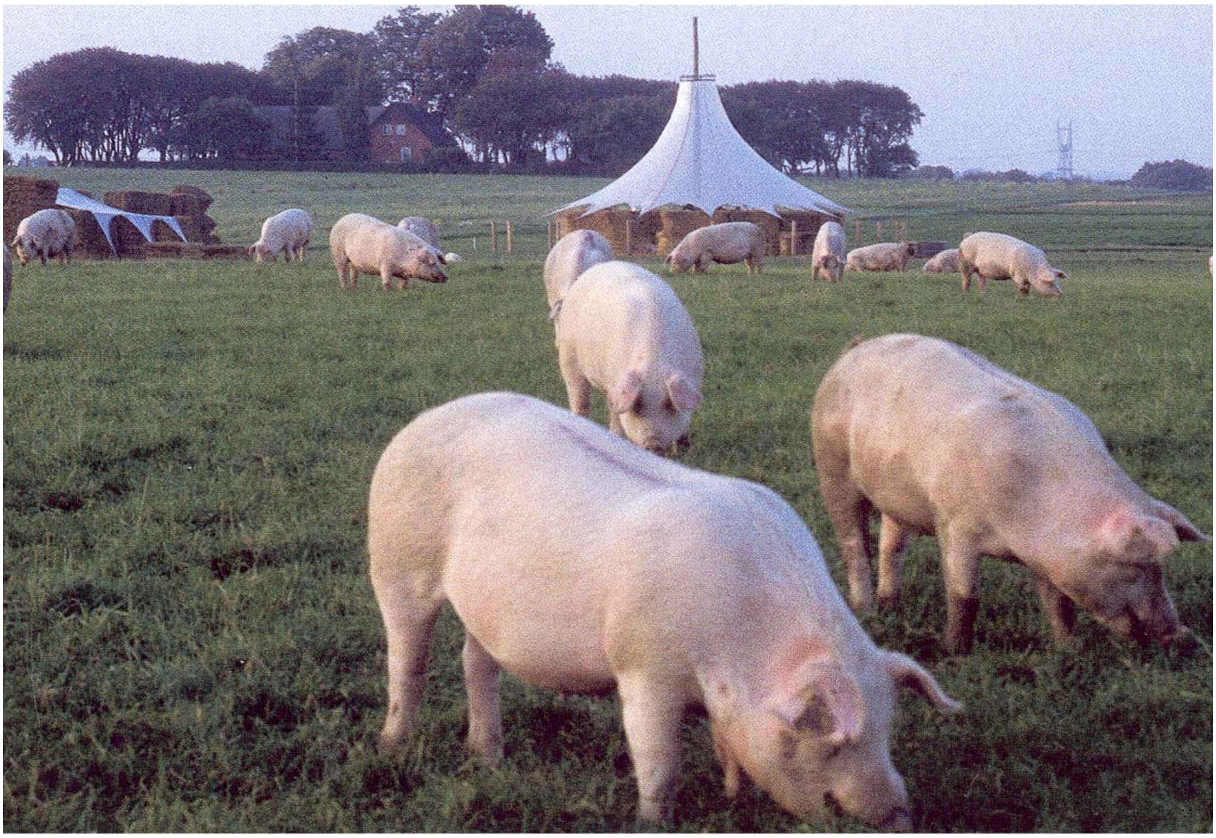

Illustration 27 Pig farm based on the life quality of the animals and on simple and practical solutions. Designed by Bent Hundorp Andersen, Manufacturer: August Olsen Efft A/S, Design Award 1998 (Danish Design Centre 2001, Jury chairman: Nielsen).

The Danish pig farm (*Illustration 27*) is an example of a design project where the traditional solution has been discarded and replaced by a simple natural solution promoting the life quality of the pigs (which are more healthy) and material and energy savings. The focus of the project was not the existing solution, but the daily needs of the pigs and the pig-farmer.

It seems from the interviews and the pilot study that stakeholders are not used to focusing on the end user of a system, especially if they are not responsible for the front line, meeting the consumers.

Some of the stakeholders obviously would like to focus more on the needs and experiences of the final users of their products but at the end of the day this is not given much priority. Every business, on the other hand, seems to be committed to their customers, which in many cases is another business and therefore not necessarily the end user of the product (system) solution.

Responsibility for user behaviour in drinking systems is therefore eliminated and not considered to a high degree by any of the actors. What is also pointed out as being the most difficult strategy in the pilot study is how to influence user behaviour in an environmentally positive direction.

A need can have many characteristics (Chapter 2.3.1 Max-Neef 1992) and so may the activity. A thirsty person would like to drink something, but this thirst may be experienced in different contexts and therefore demands different types of solution. The need can also demand solutions across the branches of solution providers. A large sports event like the Lillehammer Olympic Winter Games calls for any number of services and products, however, presented in a holistic system. Other needs, such as a person's mobility in daily life, include several types of mobility needs. If a mobility provider (e.g. public transportation) is looking for total commitment from the passengers in their use of their service, several needs and activities would have to be addressed. This starting point invites networking between branches, businesses and organizations. The end customer would be the connecting point and supply the premises for any solution.

In the Lillehammer ’94 Olympic Winter Games the starting point was a huge service and sports entertainment event. However, this is not mentioned as a prime mover. The *potential behind* the arrangement of this event seems to be a stronger prime mover both for the financial sources and the designers. The Norwegian “self portrait” expressed in the visual profile was of great interest to many stakeholders.

The vision, on the other hand (Chapter 6.3.6), addressed both the experience of participating in the event and values that should be included in the Norwegian “self portrait”.

The DSB reference project is very clear in its focus and starting point, aiming at the customer or passenger, however, it may be necessary to distinguish between the *prime movers* for this starting point and the specific interest for it. If the customer/passenger experience is the starting point, this may be the means for financial and strategic business prime movers.

8.3.2 Networking and business strategies

The factor 10 design methodology is based on the idea (chapter 3.3) of co-operation between companies and designers (consultancies) to reach more holistic solutions for products and systems designed with a user-oriented profile. In the STD (1998) project, dwellers in a chosen area in the Hague were also invited to develop future scenarios for their own living area in 2040. The results were used as an inspiration for the researchers and companies involved in the project (Jansen 2000).

Norwegian companies are often based on technological core values, or are focused on certain functions. One of the “reality-check” respondents (A2) has experienced that for typical Norwegian companies design is only a means to an end and not the actual business concept itself. He points to the importance in any networking project of asking the question of “why should we establish a network?” The respondent refers to an example of a starting point for networking. A network project for furniture in Sweden was based on the need to become visible in a vast global market. They concentrated on developing a collection promoted by the same brand and marketing profile.

Other issues that were seen by the interview respondents in the pilot study as good reasons for initiating networking with other companies or organizations were:

- Exchange of environmental data, and co-operation internally in the branch promoting an environmental profile in dialogue with legislators, NGOs and customers in general. However, the interviewee who suggested this connection point for networking denied the possibility of any co-operation within the branch on a product design level. On the other hand, this was an interesting approach in terms of co-operation with their business customers. Co-operation already exists in many ways today, but often in more formal ways.
- Innovation on a system level is an important issue for some companies; this is, however, mentioned by the interviewees in connection with the technological aspect within system development.

The various companies have an individual focus and are interested in co-operation on different levels on development and other intentions. Clear conditions for the co-operation might be important, and as one respondent mentioned, there has to be agreement on what information and knowledge the partners see as open.

8.3.3 Prime movers (drivers)

The prime movers behind the initiation of a project have a different nature than the starting point of a factor 10 project. For example, a municipal politician who is responsible for public transportation wants her political party to be re-elected and therefore this wish becomes another prime mover, and the one behind the starting point for offering the passengers (who are voters) as good a service as possible.

The prime mover in a business is still the economic vision, however, a company also consists of individuals with personal aims and ambitions, and these vary from person to person. The head of design during Lillehammer ’94 wanted his colleagues to respect the final results of the design programme, but he wanted to change LOOC in terms of acknowledging design as a strong strategic tool as well. However, the starting point for LOOC was an extraordinary sporting event and the task of exposing an image of Norway to the rest of the world of television broadcasting. Economy and marketing shares are underpinnings of all business activity. A stronger and more conscious user relation should not be seen as a contradiction to such aspects.

Brezet, Hemel (1997) present the external and internal prime movers in a company in terms of introducing eco-design. Executing factor 10 design projects interferes with the strategic thinking of a business so the personal prime movers must also be appealed to. The individual prime movers were also mentioned as important by designers in the Lillehammer ’94 project.

“They had their needs as designers, one of the goals was to make architecture and design that Norway could be proud of; this included more personal goals which the rest of the organization committee was not so interested in.”
C2 Head of design, Lillehammer ’94

Innovation is mentioned in the deep interviews as a prime mover for the pilot-study, seen from the company perspective. Next to inspiring the participants themselves, this was a key-word, which was of great interest to the executives. This also corresponds to other research, Leo Jansen (1998) and Sherwin (2001), but the aim towards innovation is also important in projects with rather incremental changes in eco-design practice (Hemel 1998).

Returning to the discussion on the starting point, innovation is mentioned in the interviews in connection with technological development and not in connection with user needs or user experiences. *Basic functions* are nonetheless mentioned as an important starting point for radical new solutions.

The focus on products and systems themselves is rather strong both in the business and research tradition when it comes to environmental issues. The challenges in changing consumption patterns and behaviour are found to be very important when analysing the results (Chapter 3, Figure 34). However, no one discusses how this focus could be a starting point for sustainable solutions.

In the “reality-check “interviews one respondent described how services are becoming the economic source in the ICT business, and therefore developers have addressed the use of industrial designers and other types of professional in the development teams. User experiences, storytelling and values are aspects all participants in the business and development teams have to think about, all the time.

“In the ICT business the future possibilities are mostly in the services provided by other stakeholders than the owners of the technological network. Nevertheless, the technology is propelling the development of new systems and products, and therefore promotes an exchange of products at a high tempo.”
A1 Associate professor and industrial designer

If innovation is a prime mover towards new or increased market shares, the innovation should be based on a need or activity. However, innovation that leads to a price reduction in production processes, for example, will not necessarily involve the final user, other than through a price-reduced product on the market.

One of the interview respondents mentioned legislation as a prime mover. However, politicians were also described as less proactive and therefore not able to pull the industry in a more progressive direction in terms of introducing solutions of a strong sustainable nature.

8.3.4 Ownership

The starting point of a project may also indicate the ownership of the project and the priorities of the decision makers.

The pilot project

For the most part the ownership of the pilot project depended on two important actors; the project head, professor and research manager, Ole Jørgen Hanssen, and the project manager in Tomra Systems, Bernt Saugen. With research funding from the Norwegian Research Council and business financial support, the project could be undertaken. The methodological approach and ownership of the project was, however, rather unclear. The drinking systems in Norway comprise a large and varied sector. A multitude of companies are involved, where some are highly exposed in the market and obvious to the end consumer and others are rather invisible but no less important to the total system.

Although the pilot study focused on Norwegian stakeholders, foreign actors play key-roles, such as the Coca-Cola Company.

The individual contributions from the companies in the pilot study were based on one or two persons per company, and this made the project vulnerable. Nonetheless, the interlocutors expressed that they were impressed by the unusual loyalty in the group attending the work seminars. One respondent mentioned he had never experienced such involvement and "gung-ho -attitude" in a project before. All the work seminars in the main project comprised a working process mainly dedicated to scenario building. A democratic process was important at this stage to arrive at rich scenarios representing as many perspectives as possible. The further parts of the pilot study where rather unclear in terms of both methodological approach and delegation of work. This required a discussion on further strategies, conceptual design and final evaluation. For practical and financial reasons this work was performed for the most part by the project head and the PhD candidate (see further comments in Section 8.7).

The pilot study had post-graduate students working parallel to the research project. This was also the situation for the pre-project stage. The ownership of the new concept ideas from the design students was, however, not based in the participating companies. A similar situation occurred in the factor 10 pilot project, when the design oriented scenarios developed by the PhD candidate were introduced in the final chapters of the main report (see Chapter 5.2.4). The interviewed participants, however, mention the students' contribution as useful and inspiring. The visualization of the design oriented scenarios was also mentioned as interesting.

The Lillehammer Olympics '94 case study in comparison with the factor 10 pilot project

IOC, the International Olympic Committee, gave LOOC the mandate to host the 1994 Olympic Winter Games. LOOC was then a clear owner of Lillehammer '94 and the organization could decide their overall approach; what projects they should initiate and be in charge of. When it comes to the design tasks, some projects were performed by external consultants and tenders were invited for other projects. The government supported Lillehammer '94 politically and in part financially. There was a clear timeframe for the process, development and delivery. Moreover, the board included major sponsors, e.g. the Coca-Cola Company, and LOOC was dependent on cooperating with important financial supporters such as Birkebeiner Lauget, the local authorities and finally the licensee sponsors.

However, LOOC was an explicit decision maker and the various partners had their specific tasks and positions in the total picture. The design processes had strong leadership and the conditions were rather open in the initial phases of the preparation for the games but were defined through a process of design experts and finally by the head of design and the first head-hunted design team (the Designgroup '94 ANS) (Chapter 6).

The two projects, the pilot study and the design process for Lillehammer '94, have important features. The pilot study is an open and experimental approach with a long-term perspective and independent premises in terms of final deliverables; whereas, the Lillehammer Olympics was a relatively short-term project with clearly defined deliverables and was certainly fixed by a definite timeframe. The experiences gained from the pilot study indicate that there is a limit to how productive a project can be when there are many stakeholders and an open starting point. Results from the factor 10 drinking-systems project should be studied further in a closed and short-term development approach for practical realization (Figure 55). Generally, it may be best to keep the factor 10 design projects more focused and dedicated with a clearer ownership. To execute and complete a design task, this type of framework seems to be crucial, next to the ability of the leaders of the process. The ownership of a project and its management do not necessarily overlap; ownership must, however, be placed with responsible executives in the organizations. Management needs to be supported by the structures in the company. Here we can distinguish between the holder of the prime movers and the holder of ownership. A project depends on stable ownership and a project leader with strong prime movers.

"Strong leadership in a process is necessary for a development process to keep the intended direction all the way through. The process or project methodology itself will never be able to carry the development as such towards the results."
A2 Associate professor and industrial designer

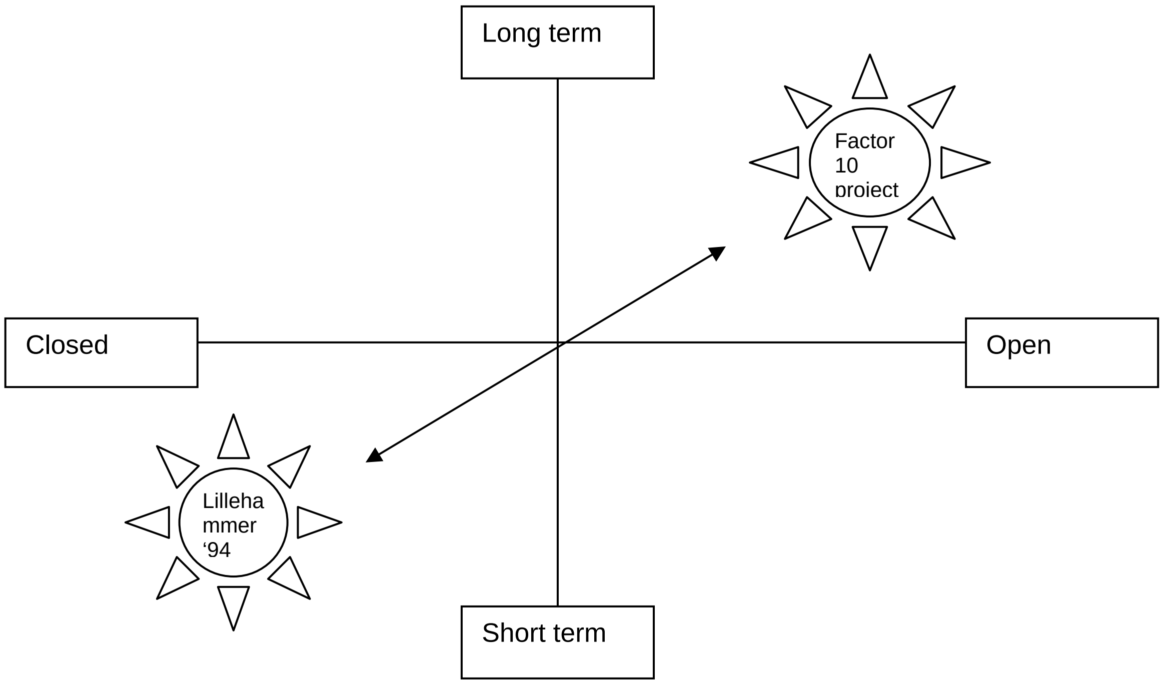

Figure 55 The factor 10 pilot study was characterized by an open and exploring starting point related to a long-term perspective. The winter games at Lillehammer ’94 were relatively closed and clearly defined based on a short-term perspective for delivery. The results from the Factor 10 project should be developed further in a closed and short-term development approach for practical realization.

The conclusion is thus that long-term thinking is a process which is suitable for open co-operation structures and “democratic” ownership. When the long-term thinking is to be transferred to present activity and solutions are to be realized, the ownership of the development needs to be clearly defined and combined with strong strategic prime movers in the companies or organizations (which own the development project).

8.3.5 Definition of scope and aims

The participants had different opinions in the pilot study as to the goal and scope of the factor 10 project. Some respondents saw the project as a cataloguing of today’s beverage and drinking systems, whereas others expected greater concentration on new solutions and development of systems for the future. The answers from the respondents seem to be linked to their professional background and education; however, this should not be expressed as a general rule based only on the four deep interviews. The starting point of a project must be consistent with the scope and aims of a project. If the starting point is open, the scope and aims might also be unclear and vice versa. In the Lillehammer ’94 project there appears to be no doubt about the scope and goals, however, there were initial processes which helped to define the scope in reasonable time. The open design discussions and informal pre-project consisted of abstract premises and criteria which gave a good starting point for the Lillehammer ‘94 design process.

Research and analyses versus design development

The two cases which are used as empirical material for this research represent two different definitions of scope for the development of projects. The pilot project is planned as a practical but open process, however, with a rather theoretical research approach. The Lillehammer ’94 project is a design project completed through clear goals, a strict time schedule and clear ownership. The head of design for Lillehammer ’94 underlined their tactical and intuitive approach based on experience and sometimes lucky circumstances. In this project the goal was more important than the methodology and process.

All the participants who were interviewed after the end of the pilot study emphasized the importance of the methodological and human processes. The project was not seen as a failure, although it yielded no practical results that led, for example, to new business activities. However, if the aim of a project is to achieve practical knowledge, the methodology should follow some of the basic principles for practical results, which includes an early, clear problem definition or set of aims (Molander 1996)(*Figure 56*).

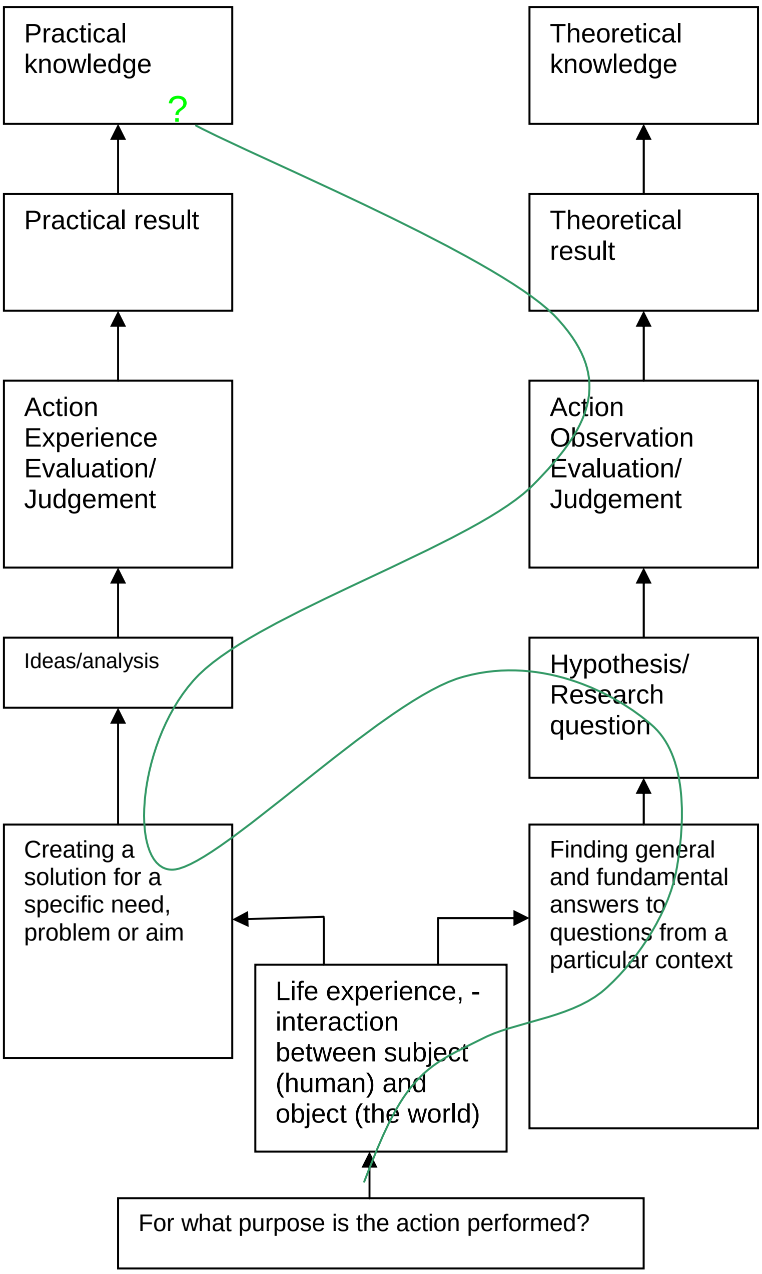

Figure 56 This refers to Molander (1996), where the development of theoretical and practical knowledge has the same source in human interaction with the world. However, if the aim of a project is to achieve practical knowledge, the methodology should follow the basic principles, including an early, clear problem definition or set of aims.

Combining the knowledge from the pilot study and the case study can give an interesting and important synergy for the characteristics of a new design methodology. The questions concerning sustainability demand some systematic and controlled processes where the execution of an innovative design process and synthesis also depends on tactile knowledge and practical experience. The results from the pilot study and the students' post-graduate work, however, show that a combination of research and practical work is time consuming and must therefore be planned carefully.

8.4 Long-term perspective for sustainable design planning

We have learned from theory and practice (the past) that decisions we make today in society and the business world will have consequences for the future, and some of them will be very serious indeed (Hueseman 2003). The next research question includes the challenge of long–term perspective thinking in the development of new solutions.

> **Q1b** How can a new methodology include a *long-term perspective* and short-term steps coordinated in the development of new concepts, and in the setting of a company and/or organization?

The long-term perspective is part of the foundation of sustainability (see Chapter 1.1 and 1.2, 1.4). This is therefore one of the essential challenges in design for sustainability. The practical obstacle is, however, to co-ordinate the short-term steps with the long-term perspectives. The following section discusses how the building of future scenarios can support long-term strategies. Section 8.6.2 examines the approach from the pilot study, while Section 8.7 presents a discussion on the coordination between long-term strategies and short-term steps in the development of new concepts. Finally, section 8.8 presents some results from the development of such projects in the setting of a company or organization network.

8.4.1 System thinking and future scenarios for long-term product strategies

In the research context

When companies are invited to take part in research projects, they have the opportunity to undertake long-term thinking and reflection, which may put their short-term tasks in a different light. This may influence decisions that are taken with a view to short-term goals. Nonetheless, it appears to be crucial that the long-term perspective work is closely related to the business strategies, otherwise the business participants will have difficulty finding the relevant bridges from long-term thinking to short-term solutions. The researchers might also have to reconsider their analytical tools with respect to their usefulness in finding operational strategies for future system and product design. For example, it may be questioned whether LCA data collection in the pilot study could have been even more useful, also in the more conceptual phase, if these analyses had been executed later in the initial phases. The motivation for LCA data collection could then be based on information about the specific chosen system with respect to users and their needs and markets, and the involved companies and their internal lives (needs and goals).

The factor 10 student projects demonstrate the complexity of focusing both on the system and the end user, in addition to the long-term perspective. The question should perhaps be changed from the *long-term* perspective to the *system* perspective. Is long-term thinking the same as thinking of the single products in systems? It might be questioned whether the complexity or problems in comprehending the issues will occur if a system perspective is introduced rather than a long-term perspective. Nevertheless, it is hard to imagine future scenarios only considering one product and not the context. Long-term time thinking therefore invites system thinking and changes in a larger system usually but not necessarily call for a longer time span.

Relation on the reality-check interviews

"The ICT infrastructure and need for long-term thinking in development of the networking technology is forcing companies to adopt a relatively long-term focus, e.g. the Bluetooth technology. In this work the visions are necessary as controlling tools for the development. The short-term planning is connected with the rapid changes in technological development. The companies constantly expect new conditions for new solutions."
A1 Associate professor and industrial designer

The long-term strategies are necessary in businesses which are connected to larger systems in development, such as Internet Communication Technology. However, short-term thinking must be coordinated at the same time. This is also the situation when designing for sustainability.

The future scenarios that were arrived at in the pilot study were based on forecasting and backcasting scenarios methodology (Chapter 3.3 , Chapter 5.2.4). This includes both statistical continuity (forecasting) and suggestions for radical system changes that are chosen on the basis of value priorities and visions. The four scenarios in the factor 10 pilot study were constructed on the basis of various changes on three axes that included economy, technology, health, demographic development, political climate and educational level in the population (Chapter 5.2.4,) This technique was based on the Delphie method.

8.4.2 Value priorities and strategic solutions exemplified in the future scenarios

These scenarios did not necessarily present the desired future, but rather different *possible* futures. The scenarios were also used as a framework for new system and product concepts which point in different directions in response to the values and external conditions presented in the scenario. The drinking-systems project (pilot study) produced a number of differentiated potential sub-projects within each strategy area.

The four future scenarios (see Chapter 5.2.4, Table 16) from the pilot-study represent values and priorities in the use of technology as opposed to human responsibility and activity. This implies, for example, the use of high-tech versus low-tech solutions. Each of the scenarios also represent differences in human personalities and needs in the future. The diversity of solutions developed in light of the scenarios can be thought of as various concepts existing in the same present within a society or on a global basis. It is important, however, to connect the scenarios with a local situation, both in terms of ecological conditions and specific human needs. This creates a passage to the next usage stage of the scenarios and further solution development.

8.4.3 Scenarios used as social and technical framework, social construction

The scenarios are described in richer detail with respect to different dimensions and the three axes (Hanssen et al. 2004). This description presents a discussion of how different elements in society affect each other and lead to consequences which are not obvious. The four scenarios can lead to deeper understanding of

- Characteristic user situations and human personalities; life phases, life situation and lifestyle
- Typical products/systems which might be representative in the scenario

This is essential for sustainable development, where the implementation of strategies should correspond to local situations and user acceptance, independent of the intention behind the solutions. However, the understanding of a user situation demands more special “investigation” through such approaches as observation, dialogue, interviews of users and customers and case studies based on use (Chapter 3.4.2). User representatives may also be involved in the further development of such things as design oriented scenarios (Chapter 3.4.2). As mentioned above, the various scenarios represent different sets of values which take different personal characters and age into account. The scenarios may be evaluated as relevant to the questions and answers from the company: “Who are our customers?” This question leadings to the next question: “Who do we want as customers?”, and “How are we meeting their needs and why?” (Markides 1997, see AppendixIV)

The individual and the social group determine what types of solution are appropriate. A social group is also culturally and geographically located (usually, but not always, e.g. global networks). The social group in this context comprises individuals who have certain defined interests and needs, but who are not necessarily connected to each other in other ways. This group is the potential market segment for a specific product and system solution, and also sets the premises for the development process.

The long-term perspective invites system thinking, but this introduces complex tasks. It might be sufficient to imagine different *user scenarios* in a global perspective which will then show that all “futures” are represented at the same time, from the nomads' ancient ways of living in the Saharan dessert to life on a satellite space station. If the needs and activities are defined as the starting point, then system thinking is also likely to occur. However, the consequences of human activity in a long-term perspective have no less basic significance for the issues of sustainable development (Chapters 2.2 and 2.3).

Several participants in the pilot study pointed to the importance of participating in future scenario building and the importance of the *working process* per se (discussed in more detail in Chapter 9.6.2).

The long-term perspective and system thinking challenge the daily perspectives of problem solving and need to mature in a continuous process. The discussion with other participants in this process was mentioned in the deep interviews as inspiring and as a source for new ideas and life views.

8.5 Short-term steps in a long-term perspective

The pilot study and the interviews of project participants revealed the frustration of short-term steps or measures in daily business activity which had no connection to the overarching long-term goals discussed in the factor 10 project. The theory, student projects and existing methodology also point to the gap between present reality and the desired future.

> **Q1b** How can a new methodology include a long-term perspective and *short-term steps coordinated in the development of new concepts*, and in the setting of a company and/or organization?

8.5.1 Transferring the ideas from long to short term

In the business context

There seem to be different approaches to this question. It is closely related to the aim of the factor 10 project. As in the Dutch factor 20 projects, "Backcasting" was introduced as the third methodological step (Chapter 3.3.3, *Figure 26*). The future scenarios were connected to the present by five–year steps involving possible developments and changes. This should construct pathways from the short steps to the long-term future scenario. However, when businesses are involved, they represent various possibilities in coordinating short and long-term goals. These may not even be coordinated in theory.

One of the participants in the pilot study is a project manager and his department. He has been able to transfer the factor 10 concept thinking into his daily challenges by setting targets: the product shall be at least 10 times more efficient both economically and environmentally in terms of material and energy use. Nevertheless, he sees that that the process of changing today's solutions in a system needs a longer timeframe. System change requires the involvement of other stakeholders, both end users and political bodies. The possibility of integrating the research results into the daily business activities seems to be more promising for the participants who have strategic responsibilities in their own business. This is in relation to innovation in product and system development.

Business strategy: short term and long term

"In general the time span of operations is very individual from company to company. It depends on the product range, the size of the company and so on. For example Nike has a logo which can be used in hundreds of variations, and is always prepared for quick moves. For NSB this is not interesting, they do not have to be "up-to-date" and change their profile every now and then, what purpose would that serve? The more long-term perspectives are interesting, and they cannot afford rapid changes, whatsoever."
C1 Coordinator for the Designgroup '94 ANS

It might be questioned if one methodology could possibly include the long-term perspective and short-term steps coordinated in the development of new concepts. The solution strategies that are chosen to reach a goal or vision will introduce development activities which have a short-term profile as well. In this view, the long-term perspectives are issues that belong on a business strategy level, and should involve the corporate executive officials who plan the profile of a company. This was the approach in the DSB reference case, where the directors of design and human resources were included on the strategic level to define operational strategies within their departments to support the company vision and future business scenario.

In the pilot study, a critical step was commented on in the movement from analyses and scenarios to solution strategies (Chapter 7.3.4). The strategies did not reflect the holistic thinking in the scenarios, but returned to the separate environmental impact indications and mostly focused on single solutions addressing single challenges.

The steps from the future scenarios towards the new system development should operate within a wide perspective to discover possible synergies between the subsystems. To introduce the user focus as a starting point of development of new solutions is a method which may connect the companies and create visible links between the chosen strategy areas (Chapter 4.2.4, Figure 48).

The designer's role changes when design is a strategic tool in trans-organizational business

"Designers are going through a change and must be able to use their methods in slightly different ways in the future to reach into the more strategic layers of businesses. Visualization and focus on user experiences in connection with a product, and the product idea, are important contributions from designers."
A2 Associate professor and industrial designer

8.5.2. System design

Parallel design thinking
Using the scenarios, we can explore in parallel the fulfilment of functions for user activities in sub-systems by means of simple overviews, for example as we have shown in closing material loops (recycling, reuse or recovery)through 1) particular kitchen solutions, 2) packaging of food and so on, and 3) recycling systems (Chapter. 5.2.4 Table 20). As we saw in the pilot study, we look at the subsystem of the life cycle of packaging by focusing on the kitchen and how the packaging solutions will affect the possibilities of closing the material loops. Through a good solution for waste and material treatment in the kitchen, we assume that the kitchen (private and public/catering) will become an even more important link in the chain of material loop closing. The participation of the public and households in loop closing is today seen as one of the weakest links in the material chain. Legislation on and demands for recycling are expected to increase in the future which will in turn demand solutions for distribution and packaging, and for the systems designed to treat the material through the loops.

From a product designer's perspective, the freedom of a project spans from detailing in the end phase of a product development to the broad initial idea generation of a new business concept (Appendix V). The parallel design method, however, can also be used with one or more fixed parameters placed in the table. The variables should then be designed within the constraints of the fixed ones (which should, needless to say, be questioned before they are accepted as fixed parameters!).

When the designer and the project team develop systems which involve several products designed in parallel to fulfil functions in new systems, this schematic presentation can be used during idea generation to keep an overview of and maintain the connection between the products in the system, all designed in the framework of values and premises in various future scenarios (*Table 22*).

Scenario/ product and system area	**Principle idea for system**	**Product solutions**	**Detailing and specific elements**
1)			
2)			
3)			
4)		.	

Table 22. Parallel design of products and systems. The table is to be read in rows. Each row presents harmonized solutions of the connected products and systems. The technology and user interface is characterized by each actual future scenario (see examples of concepts in Chapter 5.2.4, Table 18 and Illustration 11).

> The intimate contact with the consumer and individual company should not be lost in the system focus. The local specific qualities are also important for the new system solution. This should be integrated in the different choices of development strategies**.**

Design oriented scenarios

The design of design oriented scenarios (Chapter 3.4.3) may follow the parallel design, based on an exploration of a particular context, human activity (customer/user) and needs in the new system design (*Figure 30*). This might point out important actors in the new concept and indicate where the process must be focused in terms of change and new development.

The design programme for Lillehammer '94 was based on the *vision and the themes* that created a platform for the visual design programme and the design tasks (Chapter 6). It also gave inspiration to the multitude of design processes. The design programme did not promote concrete solutions but was suitable for both short and long-term projects. The design programme included strategies for long-term thinking on reuse in the relatively short-term main projects and architectural tasks. It also included historical references and natural sources for material use, aiming for modern aesthetic expressions based on Norwegian traditions. These strategies were based on a set of values that were agreed upon in the planning of the development of the Olympic Winter Games in Lillehammer '94.

The design process began four years before the winter games were opened, and this was seen as too short a time span for some tasks, such as development of original-designed mass produced products.

The reference project, the development of a new business profile for DSB (Danish Railroad Company), mentions a seven-year period for "only" changing a company profile.

The preparation for composing a system and product vision, the vision itself and definition of subsequent criteria leave a set of values which should guide the idea generation and be used later in the evaluation of the new concepts (see Section 8.9). The sustainable values, however, need a clearer identification already in the pre-initial phases. Section 8.7 will discuss this preparation. However, the development of change and new system and product designs are long–term activities to some degree. The time and resources must be present to achieve good results.

8.6 Factor 10 design projects in the setting of a company or organization

The field of eco-design and design for sustainability can present many case studies which have focused on daily business routines and others which have not used businesses and are pure research projects. Sections 8.4 and 8.5 have presented some of the challenges in the combination between long-term thinking, short-term activity and the business context. Finally, for research question 1b, this challenge will be discussed further.

> **Q1b** How can a new methodology include a long-term perspective and short-term steps coordinated in the development of new concepts, and *in the setting of a company and/or organization?*

The last issue in this question concerns the premises for a factor 10 design project, or a radical design process that will give successful company and organization co-operation today.

8.6.1 Realization of concepts

Designing a design programme and design handbooks

The methodology for Lillehammer ’94 shows that the development and design process required many steps before the direction (vision and themes) was found, and the right amount of resources was made available for the design department.

The pre-project was necessary in the process of addressing whether LOOC needed designers at all. The design programme itself was a process in defining a common design platform for a holistic profile. The design handbooks and the follow-up procedures with licensees, communities and sponsors were the pillars of Lillehammer ‘94 in the actual use of the design programme and the completion of the holistic visual profile (Figure 57).

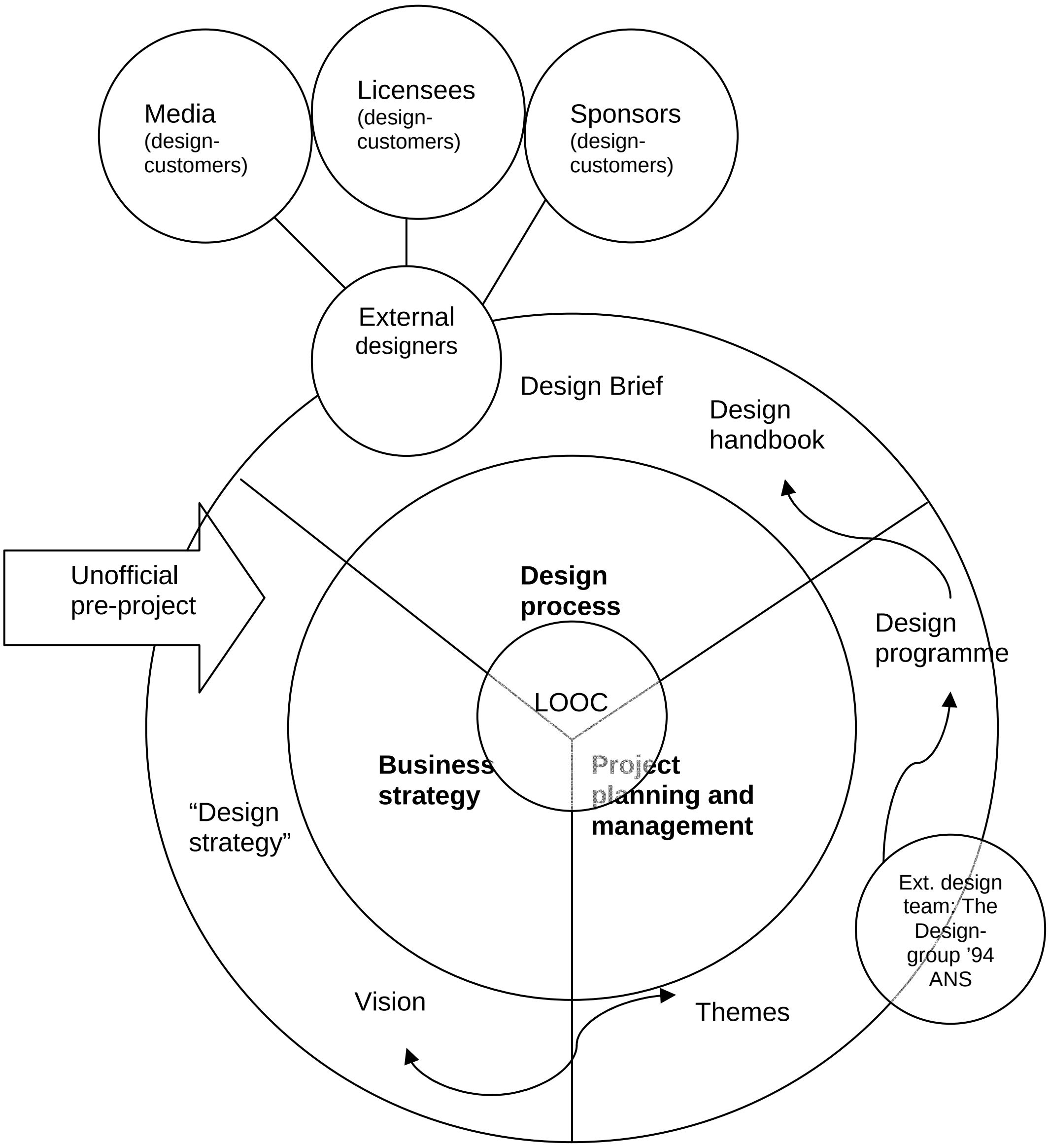

Figure 57 Stakeholders, focus and steering tools for the design process for the Olympic Winter Games Lillehammer '94.

> ***"Many companies make a design programme but for some reason don't have the strength to follow it through all the way, it might be that they don't find it important enough, and don't give it high priority all the way through*.**"
> C1 Coordinator for the Designgroup '94 ANS

Who is the methodology for?

As discussed in Chapter 9.3.4, the ownership of a project is important to the process and for progress. There can be different types of ownership in factor 10 projects. Two types have been included in this research. The first is shown in the pilot study, where the researchers propose that a mature company should get involved in this type of project and then invite other companies which are involved in similar or connected business activities The second type of ownership is a public authority or agency, such as the leadership of a municipality which is requested to find new and environmentally-friendly solutions in a long-term perspective. In the case of LOOC, the Olympic Winter Games committee had a clear leadership that was given its mandate by the Norwegian government and the IOC. However, other development tasks, such as public transportation and efficient infrastructure, are the types of area that require municipal ownership and where a factor 10 design methodology may be of interest. The human and ecological issues of sustainability are a natural part of a long-term focus, especially for companies working on issues connected to societal common goods and welfare. This methodology would therefore also be highly relevant for these buyers of design and development, including municipal authorities.

Companies in cooperation based on a common vision and strategies

In Lillehammer ’94 the licensee companies were forced to follow the design programme and handbooks. There appeared to be occasional conflicts on this issue when companies with long traditions with other strategies had to obey another profile. In an ideal factor 10 project, however, it may be possible to involve designers from each of the companies and give them a mandate to design a common design programme for sustainable solutions. However, the companies should have had a closer connection to each other with respect to business areas than in the case of the pilot study. The goal and vision in the pilot study became too wide or vague because the businesses did not see any clear common goals in the project. The goals should be motivating and become important prime movers in their own right.

The vision for Lillehammer ’94 was made by the management team; the themes for the design process were made by the head of design. As expressed by the interview respondent, for unknown reasons, the vision and the themes harmonized and therefore became good and inspiring sources for the visual design profile. In co-operation between many stakeholders there may be a conflict between the individual company’s visions and strategies and the common vision which should be the guiding light for the larger collaboration.

8.6.2 Human processes (setting for the teamwork, tools for communication and visualization)

The pilot study and Lillehammer ’94 were projects that depended on individuals and their *processes in communication* with colleagues and other stakeholders, either to motivate and involve or to convince in terms of priority, acceptance or understanding of the issues of sustainability and/or design.

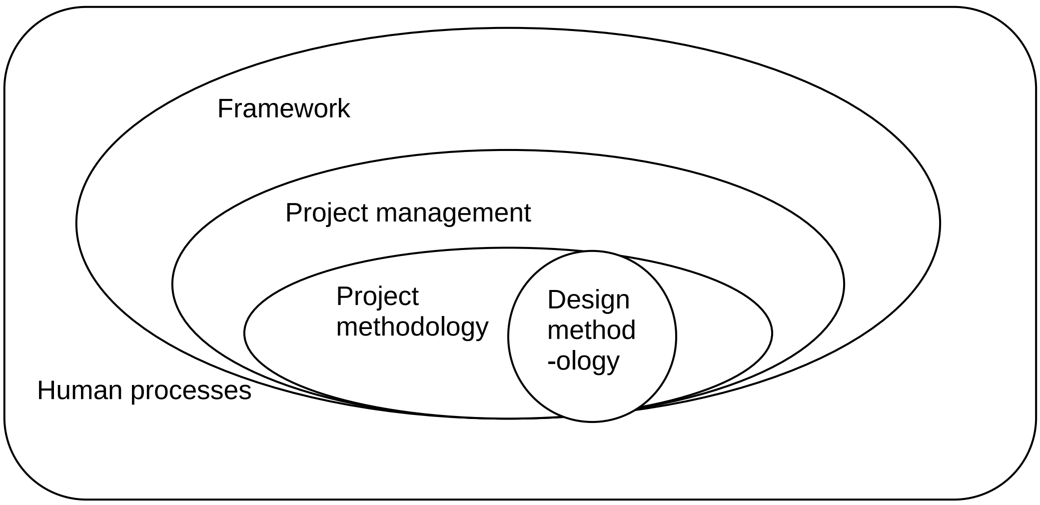

Figure 58 The human processes are important in every aspect of the project. A methodology itself will not be able to carry the process and promote progress in the right direction.

The figure illustrates how the human processes are the foundation for all other activities, such as creating a framework for a design project, confirming management, executing the development methodology and finally choosing the specific design methodology. Both the case study and the pilot study show examples of important methods concerning the human processes. The pilot study introduced a shift in work location, travelling to a cottage with an informal atmosphere and evoking open discussions and a multitude of contributions.

A business participant in the factor 10 project expressed the following in the deep interview:
"Creating change in how an entire company works requires the CEO to go through this type of process. Totally different thoughts and capabilities are necessary to cooperate with other companies. Openness is also necessary, which is probably more difficult on the higher levels in a company. It might be hard to have the same type of process on a higher level simply because people in those positions have other types of personalities."
B2 Project manager, R&D

Motivation and ownership

Motivation, involvement and ownership were mentioned in the interviews on contribution in the processes (*Figure 59*). The design manager for Lillehammer '94 used the term motivation as a synonym for ownership, however, his approach to motivation was involvement through telling about the design process, the themes and the vision, and showing ideas and early-stage concepts. This was presented according to the recipient's premises regarding who was encouraged to contribute in this mega event. One respondent from the factor 10 project mentioned the importance of project ownership for being motivated to make a contribution (e.g. in terms of data).

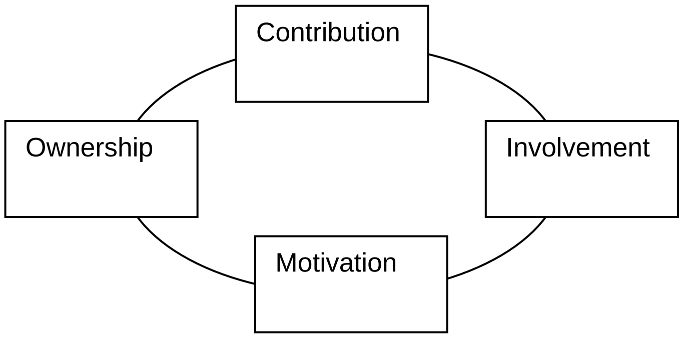

Figure 59 The human issues such as feeling of ownership, motivation, involvement and contribution seem to have close connections in the teamwork.

Crucial aspects for practical success

The head of design for Lillehammer '94 and his designers communicated with their colleagues in LOOC and other stakeholders through visual presentations and storytelling to achieve understanding and support for the design programme. The systematic use of presentations and visual communication gave ownership and motivation for involvement in use of the vision, themes and total profile for the Olympics (Figure 60). The head of design, Petter Moshus, used both emotional and rational arguments, and presentation techniques were necessary to create a successful network committed to the design programme.

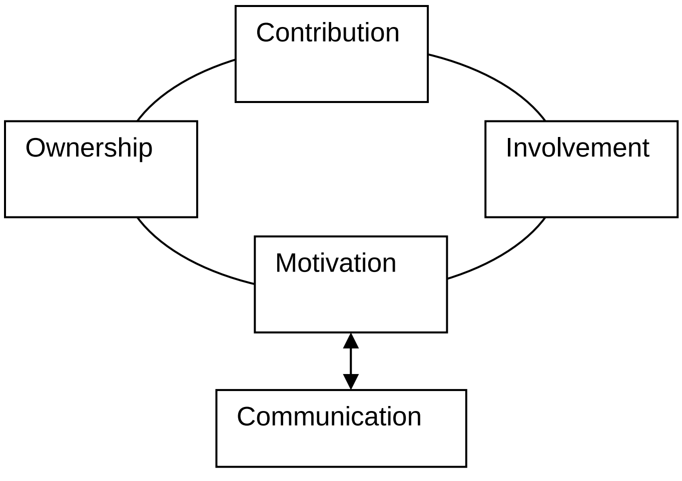

Figure 60 Communication through visual presentations was used extensively to motivate new partners and stakeholders to get involved in the winter games.

Personal engagement and "off campus" workshops in pilot study

The four interview respondents from the factor 10 project all focused on the scenario work as important and useful. However, only one of them had specific considerations about the aspect they are useful for. The work method, however, gave the participants experiences which where useful in themselves for human relations on a professional basis, and also in informal settings and open, creative discussions (*Figure 61*). Several respondents evaluated the process higher than the result. The project work included the views of all the participants, which seemed to increase the individual feeling of ownership of the project. The project manager summarized the contributions after the sessions and presented the final scenarios in the closing report (Hanssen et al. 2004). Absenteeism was remarkably low among the participants during the three two-day sessions.

"The factor 10 project showed very good continuity, and this was dependent on each participant and the personal interest in the project. This was probably the consequence both of the theme, which was related to their daily work, and also how the work process was organized. The participants were probably driven more by their own motivation than by the company strategy or the attitude on the environmental profile."
B2 Project Manager, R&D

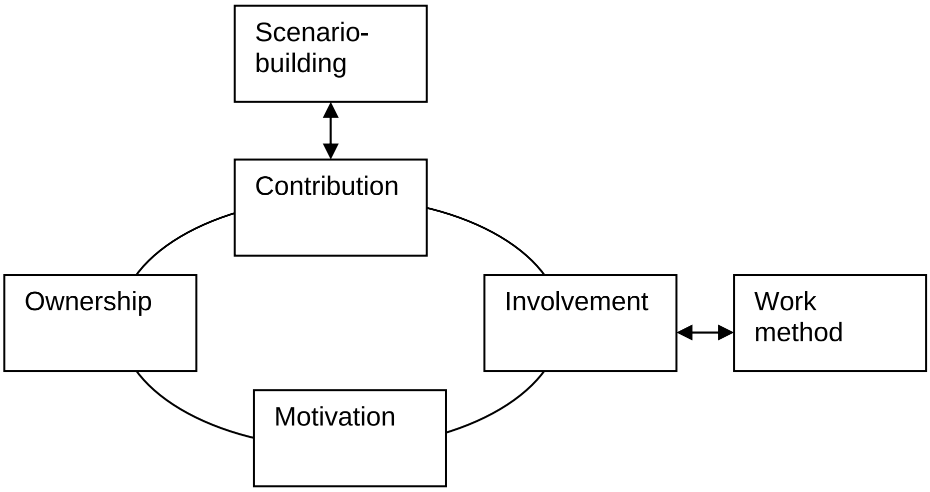

Figure 61 The work method in the pilot study led to involvement and active contribution which was necessary in the work on the future scenarios.

Future scenarios and holistic perspectives are quite a contrast to the specialized daily work of many business employees. The respondents from the pilot study all mentioned the necessity and importance of changing the working environment so they could think in totally different ways than in their daily routines.

8.6.3 Holistic thinking

The International Olympic Committee has its own values which it promotes in every Olympics. The Olympic Games as an ancient ritual also represent values which to some extent are preserved in the modern version of the games. These values, however, are evolving according to new impulses from the Olympic hosts, and because of pressure and discussions in the international community. Environmental issues and democratic principles within in IOC are examples of perspectives that have been highlighted by Norwegian NGOs and other stakeholders.

The vision as value-carrier in the Lillehammer '94 design and development process

The discussion on Norwegian values and Norwegian expression was a complex issue. The Lillehammer winter games represented a special context since the entire Norwegian population felt that as a democratic nation and culture every individual was in position to introduce a personal opinion about the visual profile and what products should be sold in connection with the Olympics. The winter games received enormous media attention and therefore the design programme, the vision and themes presented to the public, interested a great many people when it came to the visual strategy that was finally chosen. Finally, as discussed in Section 8.3.4, and commented on by an interview respondent (A2), the design process is not a democratic process and therefore it might be crucial that one has strong leadership and individuals with the ability to decide directions and means. This means that a variety of interests and needs should be taken into account, but the final decisions are made by a small group, or one person in charge.

"A vision can, and should, satisfy the company's future strategy defined by a particular number of key factors. It must give the company a unique character, both visually and verbally, and give the company an image through the brand; telling the environment, surroundings and target groups (internally and externally) who you are, who you want to be and what you want to achieve. This includes all visual elements and of course the company's name".
C1 Coordinator for the Designgroup '94 ANS

Strategies and criteria for new solutions

The unofficial pre-projects for Lillehammer '94 introduced abstract perspectives for the Norwegian Olympic design. They discussed the importance of presenting a clear message; what was particular to the Olympics and what was the surrounding culture and Norwegian promotion in this situation. The report also warned against clichés and underlined the unique possibility of holistically promoting both Norway as a modern high-tech nation and a country with long traditions and an everyday culture that was close to nature.

The final vision for Lillehammer '94 was described after the pre-projects, and included values based on non-material values in human relations and experience (Chapter 6.3.7).

The design programme with the design handbooks was designed on this basis and functioned as a design brief for the sub-projects integrated in the visual profile.

8.7 Defining qualitative sustainable principles, guidelines and criteria for design concepts

The estimations for the future present a clear picture of the will to change the material and energy consumption on local community levels to meet the global need. This means that the changes have to be based on sustainable principles, as opposed to the development and changes that have been dominating industrialization from its inception to our present time. In the initiating phases of a design process for a new system design it might be difficult to evaluate the direction of the change. The environmental profiles have so far been presented through quantitative analyses. This is not seen as suitable for ideas which are on a qualitative principle level and still relatively vague. The next research question addresses this challenge.

Q2 How can design concepts be evaluated in the early phases of the design process when it comes to their ability to contribute to a future development in a factor 10 direction?

The measures of sustainability depend on the specific context of the solutions, with the exception of some major principles (Chapter 2). The further guidelines and criteria supporting the sustainable profile of a new solution must be discussed and catalogued before idea generation starts, and as a part of the research phase.

> **Q2a** How are the different principles of sustainability, guidelines and criteria defined for the new concepts?

Before these questions can be answered, *sustainable principles, guidelines and criteria* should be discussed in general. The theory in Chapter 2 presents the ecological perspectives of sustainability and human aspects, such as quality of life, fundamental needs and satisfiers which can be found in different phases or states (Max-Neef 1992).

8.7.1 Sustainable principles

By following the argumentation in Chapter 2 and inspired by the three philosophers Arne Naess, Martin Heidegger and Hans Jonas, who are Western philosophers influenced by Buddhism (Naess) and Taoism (Heidegger), we might be able to draw some principles for solving eco-design problems.

The principles include at least three aspects:

- How to embrace the human experience in the encounter with a product, by this we mean that it leads to spiritual activity such as reflection, creative activity or conscious development with consequences for choice of lifestyle and priority of values.
- How to include the cultural and social perspective, and then to promote product life cycles that are sustainable with respect to ethical issues, local adaptation, contribution to the majority and human possibilities of empowerment, such as personal influence on daily work (e.g. in the production of products, repair, recycling systems, and so on)
- How to connect with nature and find material and energy sources, and cycles from biologically (naturally) produced "products" which are transferable to human mass-produced products.

8.7.2 Guidelines and criteria

Guidelines are suggestions for promising approaches to the specific issue addressed in the design task. The guidelines should integrate the three areas of principles presented above, however, they must be more specifically oriented towards the actual problem definition. Moreover, sustainable criteria descriptions are required for necessary, favoured or desired details and standards. The criteria support the chosen guidelines and specific tasks when working out the details of a total solution.

Defining the relevant sustainable principles, guidelines and criteria for a new concept depends on time for reflection and discussion in the decision-making processes, from business to product level. Personal development and characteristics of the participants will influence the decisions but so will the method and tools for discussion.

From this perspective the sustainable principles will enter very early in the design phase and even before the design process has been initiated. The guidelines link the principles to the more specific development (or business concept) task. They influence the solution strategies that are acceptable with respect to a vision of sustainability. The criteria will enter the product specification and the product-detail phase. The design process itself is only one of many important processes in the business as it moves towards sustainable solutions. The principles and guidelines are linked to the business profile and strategies.

One of the respondents in the "reality check" deep interview has a corresponding view on this conclusion:

"From an ecological or sustainable perspective, the strategy concerning these issues should be on a business level and not only on the product strategy level. Presenting, for example, two sustainable products among 20 traditional products does not make sense in a holistic corporate profile."

A2 Associate professor and industrial designer

8.7.3 The matrix of sustainable principles, guidelines and criteria in design

When the levels of sustainability are connected with the design process and the material solution, another three areas are extracted from the sustainable principles:

- the orientation, which is the non-material view and context that a solution is made within and based on
- the system flow, which is the material flows of energy and materials that the new solution is a part of
- the human activity and the individual experience, which is the consequence of a solution or is the starting point for new development

The matrix below (*Table 23*) has been experimentally filled in with theory and principles mainly from the material in Chapter 2.3. This matrix is developed further and presented in Chapter 9.3 as the thinking map (*Model 6*).

	Orientation	**System flow**	**Material solution**	**Activity and experience solution**
Sustainable principles	Human beings can control technology if they first understand its *essence,* which is they can do through the understanding of the human being. (Heidegger) Ethical issues leading to a conscious choice of lifestyle or priorities of values. Awareness of human relation with nature	The extraction of resources should be based on renewable materials, fluids and energy. Replacements must be found for toxic processes and materials which must be avoided as much as possible throughout the life cycle of a product system. Bio-materials should be separated and led back to organic processes.	The real innovation is to go beyond the obvious and to truly understand what is behind what people are saying, and create products or systems that satisfy these needs (Markides 1997).	Personal understanding/ awareness of one's own connection with surroundings and nature – *Ecosophy* (Næss) Meaning and quality of life.
Sustainable guidelines	A path to the understanding of the human being is interaction with nature, fine arts and crafts (Heidegger) Language, poetry, culture and social patterns	Through e.g. life cycle analysis, a company will gradually become more aware of the life cycles of its own products, and each operation in the production process will be evaluated in a holistic setting. This may bring the employees closer into the process and point to the importance of their specialized work and how it contributes to the whole. The specific setting should define the appropriate use of materials, energy sources and type of consumption	The connection between local conditions, cultural traditions and industrial mass production may give interesting characteristics to the product solutions which are carriers of both material and spiritual values, contributing to more holistic product-system solutions for sustainability. (Walker)	The nine fundamental human needs (Max-Neef 1992**)** **Material:** Subsistence Protection **Non-material:** Affection Understanding Participation Leisure Creation Identity Freedom
Sustainable criteria	Art and nature are carriers of rhythms and rituals, and can keep alive and explore the sense experiences in	By using local resources to a much higher degree, a greater diversity of products may appear. Connecting life cycles/spirals and	Living with products. Repairing, maintaining and living with the change of a product has become a	Interesting and meaningful activities and experiences can be enjoyed for free Library Hitchhiking Playing games

	people's life, and can also contribute to common important experiences. (Dewey)	"credo-to-credo" thinking are principles from natural systems.	strange and scary thought to many people in the developed part of the world. (Tonkinwise) Understanding the process gives meaning to the object (Dewey)	Telling stories Being with friends

Table 23 The table explores the principles in connection with the material and non-material issues for qualitative sustainable evaluation in the design process.

8.7.4 Initial analyses in development projects

Different and compensating characteristics of qualitative and quantitative initial analyses are necessary to understand the problems with today's solutions and to see the need for changes and approaches for new sustainable products and systems. However, a development project is an iterative process and the type of analyses which are carried out should be carefully chosen depending on the challenges and needs for additional information during the design process. Searching for completeness in the material through research methodology is not necessarily the best approach in the initial development phases.

The pilot study was initiated by analyzing the existing drinking system. This was used as a reference system for improvements. It is debatable whether the results were useful for new development in terms of the working hours spent on this process. Nevertheless, this may be useful in a communication process as argumentation for the potential in new developments.

"The time spent on data collection would never have lasted that long in an industrial project. But with respect to others' tasks in the project, this was accepted; however, I found the amount of time spent on details in the data collection and analyses disproportionate to the rest of the project. It is sufficient to have an approximate picture of today; if the aim is to reach a factor 10 level in the future."
B2 Project Manager R&D

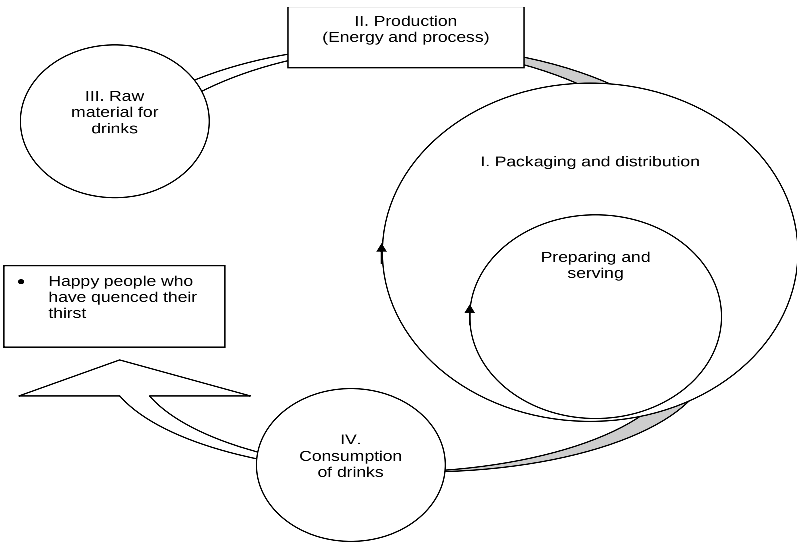

Figure 62 Abstraction of the life cycles interacting in the drinking systems

In the pilot study, the ecological impact from the drinking systems of today was screened by gathering data on the different partial systems connected with a reasonable holistic picture (Figure 62). This included drinking products, such as spring water, coffee/tea, milk, mineral water, fruit juice, beer, wine and spirits. Much of the data are still under review and are insufficient (according to LCA standards for data quality), but at this point some important sources of great ecological impact could be extracted from these systems:

- The traditional agricultural systems which deliver many of the basic ingredients for the different types of drinking products are responsible for many types of ecological disturbance (such as eutrophication and toxicological impact).

This is an impact that comprises a violation of one of the sustainable principles, namely that artificial products should be parallels to biological or natural “products” and to the natural system flows.

- Health risks arising from insufficiently cleaned drinking water.

The human being is also part of nature. Similar to animals, we are affected by substances which originally do not have a place in the ecological flows. However, health risk may also be caused by water that has never been suitable as drinking water for natural reasons.

- Large leaks in the drinking water distribution net and an unnecessarily high degree of water cleansing (e.g. used in manufacturing processes)

This is a product system weakness and is not related to a sustainable principle but rather to guidelines on how these types of solution should be designed. Locally related solutions and tailor-made installations may be both more sufficient and effective in this particular situation. However, the centralized systems can also be representative for sustainable solutions; every case must be evaluated individually.

- Transportation(fossil fuels) and use of packaging for the end products (material waste)

This solution was connected to the sustainable principle concerning the biological parallel and in this case was the wrong choice of fuel, namely fossil fuel, which is not renewable and is extracted mechanically in high amounts and brought into the biological cycles. The waste from packaging is connected with the same principles through lack of life-cycle thinking and non-renewable material use (plastic, which is from fossil resources). When it comes to packaging, there are most probably some sustainable guidelines and criteria in terms of system and product solutions that could be introduced as improvements.

- Use of energy for cooling drinking products during the product life cycle

The amount of energy use is important with respect to sustainability, even if the consumed energy is extracted from renewable sources (Hueseman 2003). The Western life style and demands for living standards are on average not in balance with “sustainable living”, which the factor 10 concept clearly expresses. The grocery stores that cool beer and mineral water in a country where the temperature outside is below zero at least half of the year, are appealing to an irrational consumers trait and hardly to “real needs”. This is touches directly on sustainable principles. However, milk and fresh juice might need cooling for reasons of durability.

Solutions which are based on a “strong sustainability” view (Hueseman 2003) could perhaps also eliminate this need for cooling by local and smaller systems. In a “weak” sustainable view (Hueseman 2003) this need for cooling might rather be a guideline and criteria issue in terms of finding better solutions (e.g. renewable energy sources) but within the same centralized and industrialized system. These problem areas discussed above were connected with the functions and activities in the reference system. Actual problem–solving methods were introduced superficially at this stage in the pilot project and are placed in a table (Table 24) in connection with the functions and problem areas. At this early stage of the project the methodology reveals several possible sub-projects for new system and product developments.

Functions and activities	**Problem area**	**Possible strategies for problem solving**
Main function: Quench thirst	**Unhealthy pattern of drinking consumption** Maintain the quality of drinking water	Offer more precise volumes of drinks Promote water as the best alternative Reduce the misuse of water, reduce the need for maintenance of water pipes and resources, look for local drinking water solution
Consume drinks	Waste, packaging and leftovers	Simplified recycling system, holistic design Tailor-made packaging
Prepare drinks, and so on	……………….	…………………..

Table 24 The analyses in the initial phase of the pilot study show the major connections between the existing system functions and related problem areas. The table also systematizes possible problem-solving strategies.

As mentioned above, one of the interview respondents was managing development projects in his company with a very clear definition of his aim: “This product shall cost 1/10 of the price of the competing product*.”* This aim represented a complete break from what they had done before. With this radical demand you cannot use anything of what you already have made through traditional ideas.

“The company undertook LCA on their product systems in the USA where the company dominates a total material chain. This was the basis for this factor 10 project. This data was very easy to generate since the company itself was the master of the data. In addition, the company provided data from marketing surveys, and communication and customer incentives. I trusted in the possibility of finding “tomorrow's system solution” based on the knowledge of the weaknesses of today’s system.”
B2 Project Manager R&D

The connection between the quantitative environmental analyses and qualitative impact categories and the sustainable principles, guidelines and criteria, seems to a high degree to place responsibility and empowerment at the proper level in a company and organization. The impact of sustainable principles is related in many situations to decisions made on a business strategy level, and therefore it will be hard for a product development group to intervene in a disconnected way with respect to direct communication with the CEO.

8.8 Chosen qualitative values integrated in the development methodology

When the strategies for the new sustainable solution are defined, they need to be transformed and enter the design process at different stages and through appropriate methods.

> **Q2b** How will the principles of sustainability, guidelines and criteria *enter the design process* to help promote and evaluate future factor 10 solutions?

8.8.1 The introduction of a vision as value carrier in the design process

A vision represents a direction and implies movement. The direction is one specifically chosen by a person or a group and more or less defined. A vision can be placed in the setting of political and societal development but also in business-related activities. Many companies today operate with a defined vision which reminds the employees of the direction of their work and externally informs other of the values the company wants to be identified with. This vision is usually of a more abstract character, but in many cases involves the wish to be number one in their activity on the market. The companies then often support their own vision with a stated mission and core values.

Furthermore, the products and systems which are designed and developed may evolve under a *product vision*. This vision is often based on a user experience which is desired in the encounter between the product and the end customer. In the Lillehammer '94 case study, the designers did not operate with a product (or design programme) vision, but *themes*. These themes were, however, compatible (luckily, as we saw) with the vision of the total event, and were of major importance as value carriers in the entire design process, from the design programme to the final products and event.

"A vision for a product should not reflect a certain time or stage, but a user experience over time. It should a) be without technological input, b) be without formalistic input c) specify the functions of the product. A vision of a company can be more abstract. It does not have to include the one-to-one relationship between the product and the user. This is the designer's strength (the one-to-one perspective).
A vision is not something that can be delivered to the company. A vision has to be integrated in the heads of the CEOs who are in charge of the direction in which the company is going."
A2 Associate professor and industrial designer

In this perspective, the vision may be a common understanding and perhaps motivation for development that points in the same direction.

Defining a vision for business and business concepts

"A good vision is defined as "wide enough to show how some new ideas of functionality will fit into the rest of the user's life." Without a broad enough vision, people will not understand your design intentions. It is the setting in which activities happen that gives the clue all the time."
A1 Associate professor and industrial designer

"A vision should never be reachable; otherwise it is not a vision. A vision is a dream to stretch for. The other choice is goals. Goals are meant to be achieved and they should go in the direction of the vision. If the vision is to reach the stars, then the first goal could be to break through the atmosphere, or to take off from the ground."
C2 Head of design, Lillehammer '94

One interlocutor refers to Kennedy's vision of landing on the moon as a good vision. It tells you a great deal about visions and how they can be unique in some ways; something to really stretch for. There should, however, be some realism in them as well. But realism is relative to your activity, the company and what you want to achieve.

Through literature studies such as "The Natural Step", and workshop and cultural studies, the pilot-project group sketched visions for the new factor 10-drinking systems. The vision was defined as follows. The future drinking system should be:

- A system for drinks which covers physiological basic needs in the population, fulfils social and cultural functions, and is at least ten times more resource and environmentally efficient than current solutions.
  This can be realized through activities such as:
  - Higher consumption of spring water as a substitute for other less environmentally-friendly and nutritious drinks
  - Customer selection of products with the lowest resource and environmental impact in production and distribution
  - Use of packaging and distribution with the lowest wastage of main product (drinks) in distribution, reuse of suitable packaging and as high a degree of recycling as possible for disposed packaging

This vision includes suggestions for physical solutions and an imperative for the customers, selecting the best environmental products from the shelves. The initial sentence in the vision promotes characteristics that the new product and system solutions should possess. However, this sentence, *"A system for drinks which covers physiological basic needs in the population, fulfils social and cultural functions, and is at least ten times more resource and environmental efficient than current solutions.",* seems to have the ability of a vision. Moreover, the content of the sentence could be described in detail by defining values. The suggested solutions for the vision include sustainable principles for natural biological solutions (water as solution for thirst), sustainable guideline for lifestyle (conscious choice of drinks) and finally principles concerning recycling (packaging material) and guidelines for recycling and minimization of waste (packaging). These are, however, *strategies* that can be followed when it comes to moving towards the vision.

Level of strategies for product system concepts

The vision should be supported by more detailed strategies for system and product development. The strategies are usually not part of the vision itself. The strategies can be placed on the principle, guideline or criteria level. The principle strategies are usually defined before the design process takes place. The guidelines are introduced as possibilities in the initial concept phase, or also before the design process as well. Only the product criteria are to be defined in the later design phases.

The creation of the vision used in design evaluation of early solution concepts

The vision with its defined values should be an inspiration for idea generation and the design process. The early concepts, however, must be evaluated for a selection leading to final result. In the Lillehammer '94 case this evaluation was undertaken on a intuitive basis and through the response from the total organization when the initial concepts for the design programme were presented. The pilot study did not enter this stage of the process. Perhaps design for sustainability also differs from the traditional design process on this stage as well. An intuitive evaluation may not be sufficient in more complex projects where sustainability is part of the desired consequences of the total solution.

8.9 Qualitative evaluation of early concepts in the design process

When the new ideas are generated on the basis of the sustainable strategies, they need to be discussed and evaluated. The evaluation will guide the selection of the most promising idea for further development.

> **Q2b** How will the principles of sustainability, guidelines and criteria enter the design process *to promote and evaluate future factor 10 solutions*?

One may question if sustainable societies already exist to some extent or whether they have existed at all. Perhaps we should even ask if such a society can exist. This is the core of the *vision of sustainability* in general; a society built on basic principles which contribute to human and ecological infinite carrying capacity (see also Chapter 1.1). Understanding and recognizing these principles is a complex undertaking and therefore it might feel like it is overwhelmingly impossible to design with these principles and evaluate the new concepts before they are completed.

Evaluation of the factor 10 solutions

The solutions can be designed in a promising way through the use of sustainable principles and eco-design strategies, but with a factor 10 perspective they are also evaluated in connection with the surrounding systems. In the case of the kitchen systems and packaging, this would be the total amount and reduction of consumption and waste, and percentage of per capita recycled material. This total amount will depend on design qualities such as usability and expectations for the solutions in the market.

A calculation can be made of the clear material aspects of the solution, but when it comes to the behavioural changes, experiments and surveys must be considered for clearer evaluation. The global perspective from the theoretical background material for this type of project must be transferred to the local and practical situations. This requires difficult judgments, for instance, how simple a function or activity can be and still be developed through the factor 10 design methodology. Moreover: Do more businesses have to be involved or can there be only one business with a single product type?

Distribution of water to the general public is an example from the pilot study. Water distribution, including drinking water in Norway, is based on underground pipes leading from natural resources to each household. All the water is cleaned or kept up to drinking water standards, even if the water will be used to flush toilets, or it just leaves the pipes through leaks in the system (approximately 30%). The amount which is actually used for drinking is 0.7 % of the total use of water entering a household per person, and 28% is used for activities in the kitchen (Hanssen et al. 2001). In a future scenario the water system should probably be redesigned to sustain the level of water quality which is needed. This affects the products involved in water distribution to households, and one solution may demand new products, such as packaging and system services for delivery of drinking water. Many of these cases are complex and demand a great deal of co-operation between companies and the authorities. Individual companies are likely to contribute to the larger picture, but the total evaluation of these types of system solutions should refer to evaluation processes that can be executed by all involved stakeholders.

The respondent (A2) with a design and research background was asked about the desired qualities of an evaluation tool used in businesses:

"Tools for evaluation should be the same for all stakeholders in the process, and especially steered by the leaders of the process. The tools should be transferable on the strategic, tactical and operational levels. It should be possible to coordinate the evaluation on different areas in the same development project."
A2 Associate professor and industrial designer

Asking questions during the entire design process is a necessary and familiar activity for designers and developers. This method is referred to by one of the respondents with a background as designer and researcher and is also, for example, a generally well-known method in terms of quality check-lists. This method can also be introduced in a systematic and conscious way in the evaluation of the early concepts. The questions have to be related to the sustainable principles, guidelines and criteria that have been chosen for the concept.

"A number of questions considering user needs and usability can often give a profile to the definition of the aim."
A1 Associate professor and industrial designer

In the spring term of 2003, students in the eco-design course at the Department of Product Design Engineering, NTNU were given questions they had to discuss in their work groups during the design process of new sustainable concepts for the purchase of groceries[10]. The students were developing a product service system placed in a given future scenario[11]:

- System perspectives: How are the local conditions integrated into the concept? What is the basic thinking in creating the cycles of the resources? How is the flow sustainable?
- Ethical values: How are the perspectives of the people involved represented, and how are they empowered within the new concept? Can the use of food and natural resources, as well as energy and emissions be justified?
- Cultural and social values: How are daily routines and behaviour affected? How does the concept involve traditions, rituals or sub-cultural specialties?
- Emotional and spiritual values: What is the intention of the concept? How is it expressed (functions and means, people, technology, materials)?
- Individual values: How do the final experiences by the users stimulate senses and satisfy basic needs?

The premises and choices of values which are emphasized by the vision should give directions for the evaluation of the early concepts. The answers to the questions should be compared to the chosen values and the material from discussions in the initial phases.

[10] Some results are presented as conceptual examples in Chapter 9.4
[11] See the four scenarios described in Chapter 5.2.4

However, further discussion and open evaluation may introduce new perspectives which did not come to mind earlier. The design oriented scenario technique widely used in the Sushouse project (Chapter 3.4.3) includes user acceptance in an evaluation process. Concepts in an early stage may be hard to understand by people outside of the process. Role-play and other more visual presentation techniques may therefore be useful for the evaluation process (Lerdahl 2001).

8.10 Premises and characteristics of the new factor 10 design methodology

The previous sections presented material discussed in terms of the research questions and indicated some new characteristics of a factor 10 design methodology.

8.10.1 Conscious preparation of human processes in the design process

Human processes per se were not explicitly included in the final research questions (Chapter 4.4). However, throughout the research human aspects in the design process are seen as crucial for breaking out of the current methodological approaches and looking at the development of new product and system solutions as a contribution to ecological and human sustainability, as well as an economically feasible activity.

The design process per se should include methods which promote the human ability of being open minded and able to see new connections (*Figure 63*). The projects will demand a change in mentality which should not be dedicated to a few individuals in a company or an organization, but rather to the entire business and especially the CEO. This is related to:

a) the integration of sustainable principles in the overall activity of the business, and
b) the idea of a user-centred starting point for development, which might open for collaboration with other companies and organizations on a system level. The initial idea behind this starting point is to include user behaviour, i.e. life style and activity patterns in daily life, however, not only to include but integrate fundamental human needs as the inspiration and guide for new holistic solutions.

Designers in teams

"Transdisciplinary projects have always been interesting to me, for example with architects, industrial designers and engineers. All businesses should be able to work like that if they have the same goal of doing things better concerning their own production. We work in a similar way on other projects too, for example with NSB (Norwegian National Railroad Company)."
C1 Coordinator for the Designgroup '94 ANS

System design requires a transdisciplinary approach and team composition. Untraditional co-operation and professions might have to discuss strategies from different perspectives to complement each other.

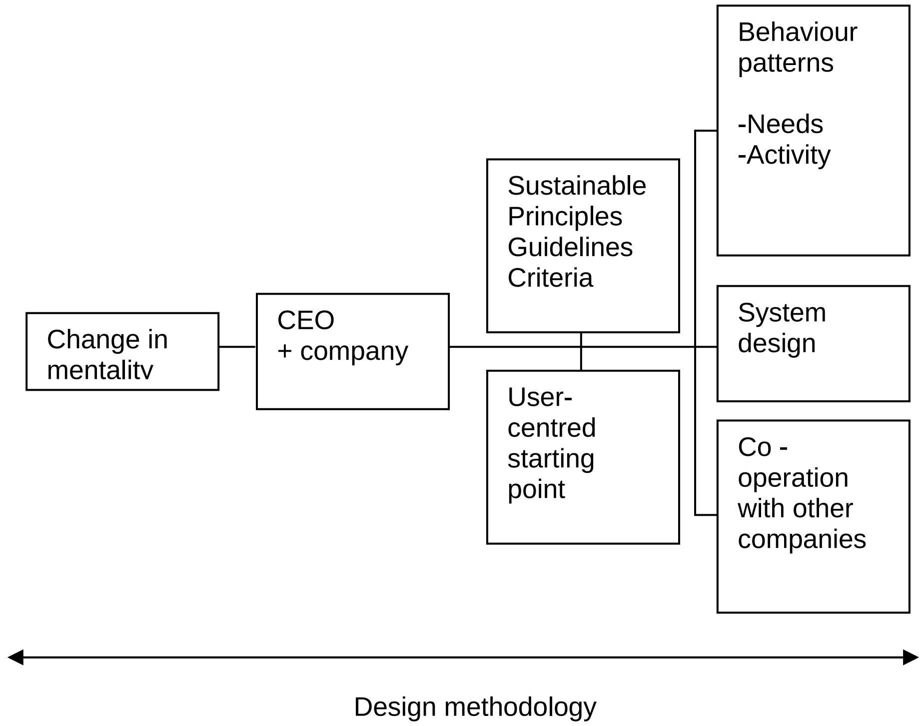

Figure 63 The methodology requires a change in mentality with respect to human focus, integrated values for sustainability and system thinking in an open co-operation with other stakeholders. The methodology may be a catalyst in itself for this shift in mentality.

8.10.2 The composing of a product and system vision as a main pillar in the design process

The vision was composed as more or less organized for Lillehammer '94 and in the pilot study. The vision for Lillehammer '94 has a clear structure with one sentence and further specified values, whereas the vision for the pilot study consisted of both values and strategies for further solutions.

The vision can be the delivery of a milestone in the design process, initiated by a discussion concerning sustainable principles, guidelines and values which are desired as representative of the new solution, as well as for the image of the businesses and co-operation behind the new development.

Idea generation and design of new concepts should be evaluated qualitatively at an early stage, based on the vision and questions which are related to the sustainable principles and guidelines. Sustainable criteria which are connected with further detailing should support the realization of the goals pointing in the direction of the vision.

8.10.3 Short-term steps made within long-term perspectives

The framework of the factor 10 project was rather open and with a long-term system perspective (2030). The ownership was somewhat loose and the deliverables were the methodology and the processes as much as the written results. The Olympic Winter Games had a clear ownership and timeframe. The deliverables for the design department at LOOC were the visual design profile presented in a design programme and design handbooks, as well as a holistic and system approach to completing the visual profile as desired.

Common for both projects was a system approach and a special focus on networking and co-operation on equal footing between stakeholders, however, within a predefined framework.

The long-term perspective was a clear premise in the pilot study, however, this introduced a detached position for the business participants in relation to their daily work. The short-term steps were not coordinated with the long-term future scenario building. The detached situation could lead to interesting new ideas and thinking, however, in the next phase of factor 10 projects the business strategies should be integrated in the long-term work. This conflict indicates the importance of a strategic synergy between the factor 10 projects and the business management and their long-term decision making.

Two complete ideas and concepts emerged from the open factor 10 project, a more closed and short-term project structure and framework should be made.

Development of a design programme as for Lillehammer ’94 could also be undertaken for factor 10 projects, but with the sustainable principles presented in a vision and sustainable guidelines presented in more specific related descriptions given as inspiration and motivation.

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...design will always be about creating something that yet does not exist.
(Nelson, Stoltermann 2003)

9.0 Description of new thinking models and a framework for the initial steps in a new radical design methodology

Some of the aims of the thesis (Chapter 5.3) are of a practical nature. The scientific results should be used as a foundation for new tools and a framework for development projects of a radical profile:

Aims

- To create a methodology for the development of holistically sustainable solutions, and alter the mindset from product to human-activity thinking, integrating human needs in a long-term sustainable perspective
- To develop an integrated tool for designers and the design team, and to guide and evaluate their concept development in an early phase of the design process while moving towards sustainable solutions.

"To create a *methodology*…" has been redefined as: "To create a *framework*…" since a methodology would require steps for the complete process (from user needs to the launched system and products), whereas this work focuses on the initial steps that define the premises for the specific design task. The initial steps include strategic work which connects the *radical design process* to business strategies and long-term strategic planning. The framework thus encourages strategic use of the design for sustainability. The procedure and tools also encourage cooperation between businesses, organizations and other suppliers of special competence to develop and design holistic solutions at the global, system and product levels. The solutions shall provide synergic satisfiers for fundamental needs (Chapter 2.3.1). The framework is supported by integrated tools which focus on the *macro and micro level* (from global and society levels to products and individuals), and on the shift from *material to non-material dimensions* (from physical objects and material flows to philosophical thoughts and individual experiences). The quantitative measurements in the factor 10 concept are goals to reach through a qualitatively ecological and humanistic focus. The framework and tools open for existential questions: Do the participants in the development process wish to enter this "room"?

This chapter will introduce *integrated tools* which are seen as instruments that can serve several of the steps in the suggested framework. The steps, from A to H, are described one by one as the results of the discussions, observations and conclusions in the previous chapters. The framework is referred to as a suggestion because every design process is different and therefore every written design methodology will function more or less as an inspiration and advice, rather than as a recipe. However, if there are some particularly important and connected steps in the framework, they involve the conscious composition of the vision of the system and product, based on discussions among the co-operating parties concerning priority of values of an ecological and human sustainable character. This specific process is the foundation for evaluation of the early ideas and design concepts generated in step G. The evaluation will reveal the possibility of the new ideas for solutions fulfilling the intended purpose and giving consequences that lead in the direction of sustainable development.

Overall, the thesis, including this chapter, is based on the view of design as a synthesis that starts from a process based on knowledge, experience and analytical activity, and depends on the interaction between the subject (designer, design team and business) and object (product and system in the context it is to be designed). Furthermore, sustainability is seen as a balance between human activity and nature's reproduction and qualities. Design for sustainability, where human needs and ecological principles are in focus, is a radical approach compared to previous design practice where the material solution and technology dominate.

The factor 10 pilot study and the Lillehammer ’94 case study, including the interviews, provide methodological experience and details for this new framework. The integrated tools are results of the theory, students' experiences, academic discussions and finally an urge to create an inclusive model for the major issues in the debate on sustainability.

9.1 The intention, focus and target group for the new models and methodology framework

9.1.1 The target group for the new models and methodological framework

The framework is useful for initiatives involving joint problem solving. The models may be used in many different types of development, and although they are made in the context of larger projects, the tools can also be useful for more simple design tasks.

The total methodology framework, including the models, is defined for

- Companies/organizations with an innovative and responsible nature
- Development of new business concepts through cooperation between several actors
- Companies/organizations in change and renewing processes
- Researchers in cooperation with companies and organizations
- Initiatives from municipalities in co-operation with businesses and others working on the design of systems and services of common goods

The total approach, however, is not appropriate on just the detail and redesign level in a company as the methodological framework affects strategic issues on the business concept level.

9.1.2 The intention behind the development of the radical design methodology framework

In the process of development and design of sustainable complex systems and products, we find a need for common visual tools where the different stakeholders find their role and agree on the vision and strategies to lead them towards sustainable solutions. Previous factor x projects had a strong technological focus (Waever et al 2000). However, the importance of human behaviour is the basis for this new approach. A focus on the end user of the new solutions is the starting point with the intention of influencing and interacting with users as customers and citizens. The system perspective is therefore seen as both the means for creating total solutions for user needs and, through this approach, as a way to promote radical changes in the direction of sustainable development.

The human focus is not enough to support and create environmentally balanced solutions.
The tools integrated in the methodology should thus also contribute to mapping the relevant qualitative sustainable principles, guidelines and criteria, and should also

- form a platform for a common vision for collaboration partners
- inspire the conceptual design phase in the development process
- function as a framework for evaluating the early concepts

- represent complementary knowledge related to figures and graphs (quantitative analyses)

Since the qualitative characteristics of the solution play the main role in the conceptual phase in this framework, the concepts have to be undergo qualitative evaluation in an early phase of the design process when it comes to their ability to contribute to a future development leading us in a factor 10 direction.

9.1.3 The priority of initial steps in the design methodology

In a design process the details and the preparation for production are seen as half of the total process, calculated in working hours spent on product development (Hareide 2004). However, the impact on changes and conceptual qualities comes in the early initial phases or even before the design process is initiated (Sherwin 2001; Verganti 1997, Figure 23). This methodological framework will thus prioritize the pre- and initial phases of the design process. With an integrated focus on human needs and qualitative sustainable principles the following objectives are included:

- Initiating system thinking and a specific starting point for participants and stakeholders
- Establishing future scenario building as possible “climates” for vision and concept development
- Creating a vision for the new solution
- Communicating the vision and values chosen for the project
- Designing early-stage concepts
- Evaluating new concepts, based on the vision and values of the project

These steps interfere with the strategic work in a business or organization. The design function is for types of projects escalated to the higher decision-making level, and can provide the premises for several specific design projects in the business (or cluster).

9.2 Presentation of the new integrated models

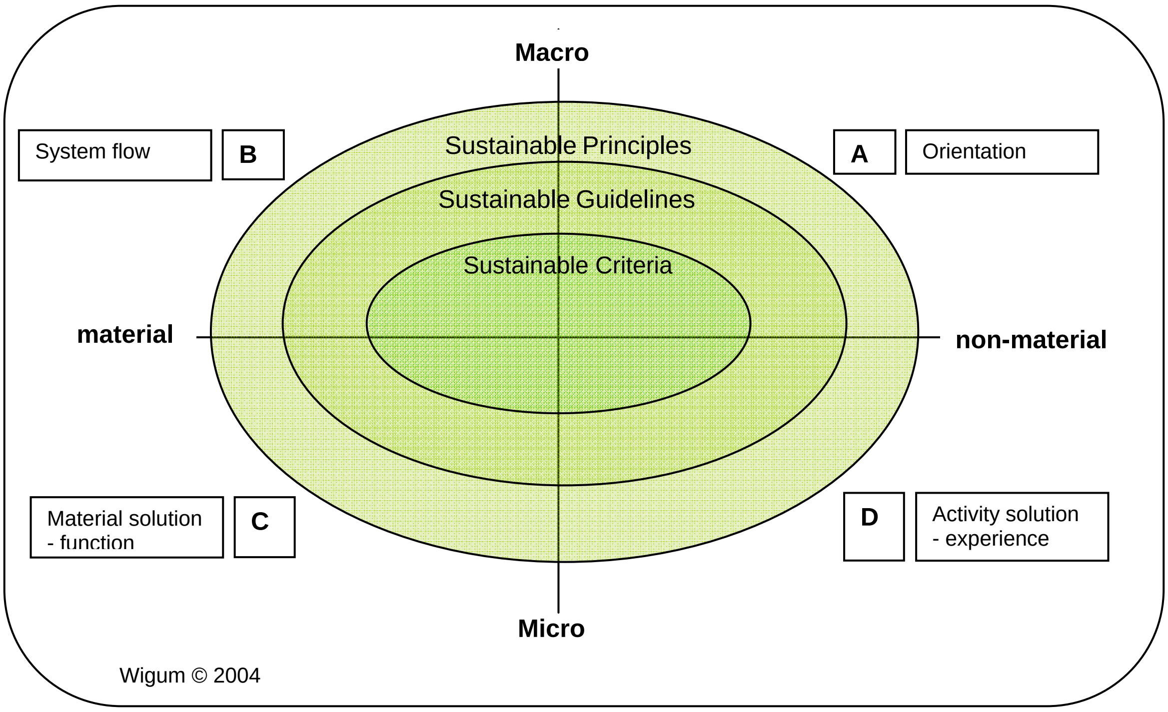
9.2.1 The main tools: The thinking model and map

Communication and holistic thinking are crucial issues in successful design for sustainability. Methods and tools can help the process and the participants by serving, for example, as reminders of perspectives to take into consideration, or aspects to analyze. However, the discussion between people and the revealing of connections between the different professional fields are of major importance for a holistic result.

It can be somewhat overwhelming to think globally *and* locally, and in terms of product *and* system, and individuals *and* society in the factor 10 projects. The thinking model (*Model 5*) is a new tool for remembering all the parameters in the sustainability discussions, but also for promoting conscious choices of priorities. The thinking model will also open for other crucial qualities in a product system solution, not only qualities that are directly connected to the issues of ecological impact and sustainability.

Areas A, B, C and D in the thinking model are represented by the horizontal ”non-material”/“material” axis. This shows that a material solution is also a carrier or is related to non-material elements and issues. The vertical “macro” and “micro” axis points to the general and common system (macro) and the specific and individual development of a solution (micro).

The four areas in the thinking model depend on each other. A decision made in area A, orientation, impacts decisions made for area B, system flow, and so on. The factor 10 concept is to this point placed in the material areas B and C, concerning global material system flows and product and technology solutions and consumption. Only the factor 10 club has addressed the social discussion which in the following model (Model 6) relates to area A orientation (macro level). However, this new model also includes individual needs and experiences, which are represented in area D. In this perspective the model represents a closed system where all parameters affect the others.



Model 5 The thinking model shows what areas of material and non-material considerations to address, discuss and evaluate in a concept development.

Area A Philosophical thinking, intention and non-material content in a human-created environment; society

The name for area A, "orientation", is inspired by Leo Jansen, who used the term to describe a future state and the direction in which society must development. However, it also includes daily human rituals, symbols and routines which have become important parts of human society and culture. This area presents the issues in the proverbial "chicken-or-the-egg" approach. What should come first, the sustainable human-created surroundings influencing human behaviour and thinking, or an awareness, which leads to the development of sustainable surroundings, products and systems? The pragmatic point of view is that there is constant interaction. The ethical questions demand awareness-raising processes in most human beings, and are therefore a challenge of a long-term nature. The deep-ecology principles (Naess 1989) primarily fit into area A, as do all ethical debates and the world views on the value of nature, political ideologies and religions and their influence on human behaviour and decision making (Jonas 1997). The intentions behind human activity are affected by these settings.

Like the circling spiral, development and change will not come out of a linear process from one start to a defined end. The meaning in a product concept is either unconsciously represented in the solution, or consciously treated through the design process. The set of values, however, is strongly influenced by cultural and social values, and here the decision criteria may be the most intuitive and hidden, or the opposite, the most explicitly developed e.g. in a politically or religiously inspired design (Chapter 2.5).

Area B System thinking for physical connections, movements and flows

This is where we find the material and energy flows, the "ecological environment". Here nature is an excellent teacher, but we must also introduce our understanding in connection with the use of technology and prime movers such as the economy[12]. The materials should flow unobstructed without

[12] Economy should be discussed in all the four areas, e.g. economic and monetary evaluation is also a reflection of worldview and ethics (Chapter 2.3.2).

degrading the quality of the material. The transformation of biodegradable materials will be of great importance in the future. This is a neglected process in most product lifecycles, whereas, “reuse”, “reduce” and “recycle” have so far been the strategies of choice. This is connected with the choice of materials. Non-renewable materials are generally non-compostable. Therefore an important step early in the design process is to ask what type of flow system should be chosen for the product and material components. Here the factor 10 concept is important as a local adaptation to the global situation. Factor x would be the right terminology as the situation in some developing countries demands a general *increase* in material and energy use, whereas in the European countries, a strong *decrease* in consumption is promptly needed. The local choices of materials in a product solution must be thought of as integrated in the larger flows, not only biologically and ecologically, but also practically. The process of returning the products and their materials from use back to the flows is a local as well as a global process. Area B contains the typical tools from the field of industrial ecology, such as MFA (Material Flow Analysis), exergy theories, and global factor x evaluations.

Area C The material solution, production and physical organization

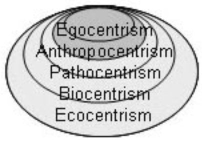
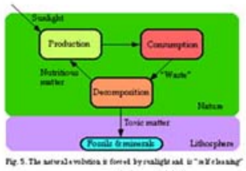
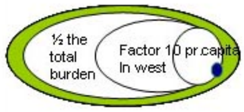
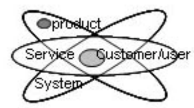
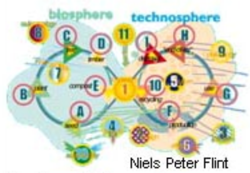
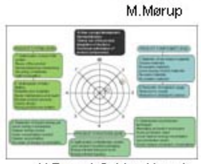
This area will be affected very strongly by the decisions made in areas A and B. This area represents the means of fulfilment. This is the area of practical and final solutions. The main functions of the concrete local solution and the choice of qualitative principle solution are defined. All this is done within the context of a user situation, including activity, needs, economics and social setting. The aesthetic totality is manifested in this area and is largely steered by choices made in the other areas. However, if there is lack of skills in this area, the intention of the product will not manifest itself visually or functionally in the final result. In addition to typical design and production evaluation methods (mock-ups, prototype building and so on), the well-known rule of thumb (Brezet, Hemel 1997) is appropriate for area C. Other mostly quantitative analytical tools are: the MET matrix, Eco-indicator 99, MIPS and LCA, LCA (Life Cycle Assessment) and LCC (Life Cycle Cost).

Area D Human activity, contribution and interaction with the product and system

The human experience through contact with human-made surroundings and products is the most critical indicator for a successful solution. The experience from this encounter may challenge the human activity to change or introduce stimulating impulses which influence the relationship between the human being and the product system or between humans. The meaning of existence and the human as part of nature are challenged in this area on an individual level. The design process should accept fundamental non-material and non-commercial values, simultaneously building on real needs and meaningful activities (Max-Nef 1991). This area can be evaluated both theoretically (Morelli 2002) and practically through such approaches as surveys, focus groups and observation. Here we find the consequences of the choices made in areas A, B and C, as experienced by the end user of the solution, but also by other people related to the activities required to complete the concept (manual production labour or service functions performed by people) or opened for as a part of the total solution. Mørup (1993) defines the encounter between the product and the user in terms of q-qualities. The product itself inhabits the q-qualities.

The four areas can be seen in relation to the three levels described: sustainable principles, guidelines and criteria. There are general perspectives within each of these areas, but also deeper discussions in each of the squares (see Chapter 8.7.3,Table 23).

As part of the research process of this thesis, the thinking model was first composed, then a matrix with the content of the discussion on energy consumption was drawn (in co-operation with Martina Keitsch). Later the matrix was developed further with the material from the philosophical argumentation and the background theory. The matrix and model have then been clarified and developed in the direction of a more user-friendly nature. However, the content of each area and the accompanying squares must be discussed and defined for each specific development project. The content displayed in the thinking map below (Model 6), indicates the themes and perspectives of discussions on the different levels, and the different areas.

	A Orientation (macro)	B System flow (macro)	C Material solution (micro)	D Activity and experience solution (micro)
Sustainable principles	 World view and intention	 www.exergy.se , Göran Wall Material/energy sources	Choice of functions for specific users and their context	Quality life, Meaning 
Sustainable guidelines	Spiritual, cultural and social preferencens Ethics and human involvement and empowerment	 Local and global connection	Principle qualitative solution :"Invited" user activity to satisfy needs 	Needs and desires **The nine fundamental human needs** (Max-Neef 1992) **Material:** Subsistence, Protection **Non-material:** Affection Understanding Participation, Leisure Creation, Identity, Freedom
Sustainable criteria	Rituals (e.g. birth, death, transformation,) Rythm (body, seasons, daily life) Artistic expression	 Niels Peter Flint Industrial ecology	q-product qualities M.Mørup  H.Brezet,C. Van Hemel	Q-qualities experienced by user M.Mørup

Model 6 The thinking map shows the content of the four areas in the thinking model.

The thinking map (Model 6) shows the content of the four areas in the thinking model. Each area in the model is simplified into three levels. The principles, guidelines and criteria levels are constructed as follows:

- *The sustainable principles*

  Within the four main areas we find some basic values belonging to the principle of sustainability, both concerning non-material and material values. The material issues are addressed in area B, the laws of thermodynamics and entropy (chaos) and the global ecological principles in nature, while in area C, the appropriate local functions in the solutions are addressed. The non-material issues are addressed in area A, human rights, different world philosophers' perspectives on understanding life connections, while in area D, quality of life issues are addressed with respect to basic human needs and day-to-day working conditions and daily life (See Chapter 8.7.1).

- *The sustainable guidelines*

  When the principles have been discussed or brought to the surface, the more specific directions and premises can guide the solution into a more precise form. On the material level this involves B, the degree of resource use (factor x) in the specific location and context of solution and C, what type of solution is appropriate in terms of technology and human-provided service. The non-material areas come closer to the concrete, through A, ethics and specific conditions for human involvement and empowerment and D, the local cultural traditions and the particular needs and desires in focus.

- *The sustainable criteria*

  In reaching the specifications and concrete solution, the material issues are included in B; specific systems for closing loops, and creating synergies with other existing systems. In C, the physical product itself and the service, if included, should be balanced with the aesthetics and technology functions throughout its lifecycle. The non-material issues in D are the desired experiences received by the users (this is crucial to the success of the product) and A, the influence on or integration with the users' daily routines, rituals and more specific activities within a societal context.

The sustainable principles, guidelines and criteria in each of the four areas will be defined in each specific development project. Background theory should lead the discussion and decisions, and every particular case needs specific discussions to define the sustainable profile of the new solution.

The thinking model and map are meant to be used over a period of time. A one-day workshop is not sufficient. The tools call for an iterative process where discussions circle around from one area and square to the other, with the aim of maturing the content and harmonizing the different areas compared with each other.

The different methodological functions of the tools are

- *For processing:*
  Thinking
  Discussing
  Communicating
  Decision making

- *For designing:*
  Analyzing
  Vision making
  Concept visualization
  Concept evaluation

Testing of the models in research
The model and the matrix have been used and evaluated in a workshop with 14 participants from various professional backgrounds. The workshop did not represent an authentic situation for the intended use of the tools, however, it gave some indications of their abilities and their readability in terms of first-impression experience. The feedback from the workshop will be referred to in terms of the different steps where the thinking model and map are integrated as tools.

9.3. Project initiation and management

Project management is a separate "discipline", however, in this section it is briefly discussed since project management is found to be highly important to a successful design and development result. Project planning was evaluated by the interview respondents as essential, both in the case study and the pilot study. Furthermore, successful human processes may be the reason for good progression, and perhaps a motivating and interesting methodology can support the human processes. This section will briefly discuss and present these three aspects.

Project planning:

The cooperation between several parties (companies, stakeholders, organizations/users, researchers)
Starting point of design project
Ownership

Human Processes:

Individual motivation, involvement and contribution
Setting the scene for different types of work

Methodology:

Initial steps from A to H with integrated tools

9.3.1 Planning and work intensity

The length and intensity of a radical design project will vary like any other project. In the pilot study, three of the four respondents mentioned that the continuity (shorter total time span and more frequent work seminars) could have been strengthened to achieve a better progress. However, the new knowledge and methodology calls for a change in mentality and the understanding of the sustainability issues requires time to mature on part of each participant and the companies. This was underlined by a respondent with a carrier background in sustainability and development research, now attending a factor 10 project (the pilot study) for the first time. He underlined the importance of working individually with the factor 10 material if we are to comprehend and understand the issues more quickly. These aspects call for deeper involvement on the part of all the participants in a factor 10 project. Working procedures can be learned from the working process in the design team for the Lillehammer '94 design programme, where each participant was delegated a task from one meeting to the next. The individual contributions were then discussed together in the following meeting.

9.3.2 The cooperation between several parties

Ownership

If the scope of the project is related to the concrete development of solutions, the ownership must be clear and the participants should be chosen on the basis of the qualifications needed in the different steps in the process.

The CEO must support the activity and contribute to the process at the stage where a vision for the project is composed. If the sustainable principles are defined for the project in stark contrast to existing business strategies, this is an initial barrier in terms of completing the total development process.

If the aim moves towards a more open direction, such as development of theoretical knowledge or more experimental research goals, then the progress is not dependent on strong ownership, however, every project depends on good and clear management.

Questions which can be useful to ask in the planning and definition of aims stages

- How does this type of project fit into the business strategy?
- How can the new ideas be integrated in the existing culture and activities?
- Are there qualified and interested people to join the project group?
- What is the economic framework?
- Is it important to arrange a seminar to supplement knowledge and provide motivation for the project?
- How much time is needed, and how much time are the involved companies and organizations willing and able to spend?

Support

- Are the CEOs supporting the project and integrating the activities into their respectively business operations?
- Is it research – does the government support such projects (financially)?
- How important is this project for the rest of the company?
- Define the internal and external prime movers

Prime movers

In his book *Factor 4 – Doubling the Wealth, Halving the Resources* (1996) Weizsâcker presents many improvements of a sustainable nature which are economically feasible but which are not completed. The prime movers therefore involve other aspects in addition to economic gain.

Demands and prime movers for environmental awareness and co-operation for radical results

The important question asked by the company is:

- What happens if we do not join this project? (Torsten Herzberg 2003, Vodafone; and deep-interview respondent B3)

As discussed in Chapter 8.3.3, opportunities and the approach to innovation are strong motivation for the businesses and also the individuals attending this type of exploratory project.

It is, as discussed above, important to include various business aspects in the radical design projects, such as long and short-term goals and activity focus. Knowledge and procedures within the various functions of a company are still of major importance.

A factor 10 or radical design project can also be seen as a “crystal ball project“. The scenario work and wider system perspective indicate to a higher degree what the vital aspects in the company's near future are. Traditional suppliers may also benefit from this type of project by being prepared for imminent issues, fluctuations in the market they operate within, environmental threats and customer needs (the needs of other companies).

Starting point

The starting point differs from both prime movers and motivation. The starting point is the angle from where the information is gathered and analyses are executed.

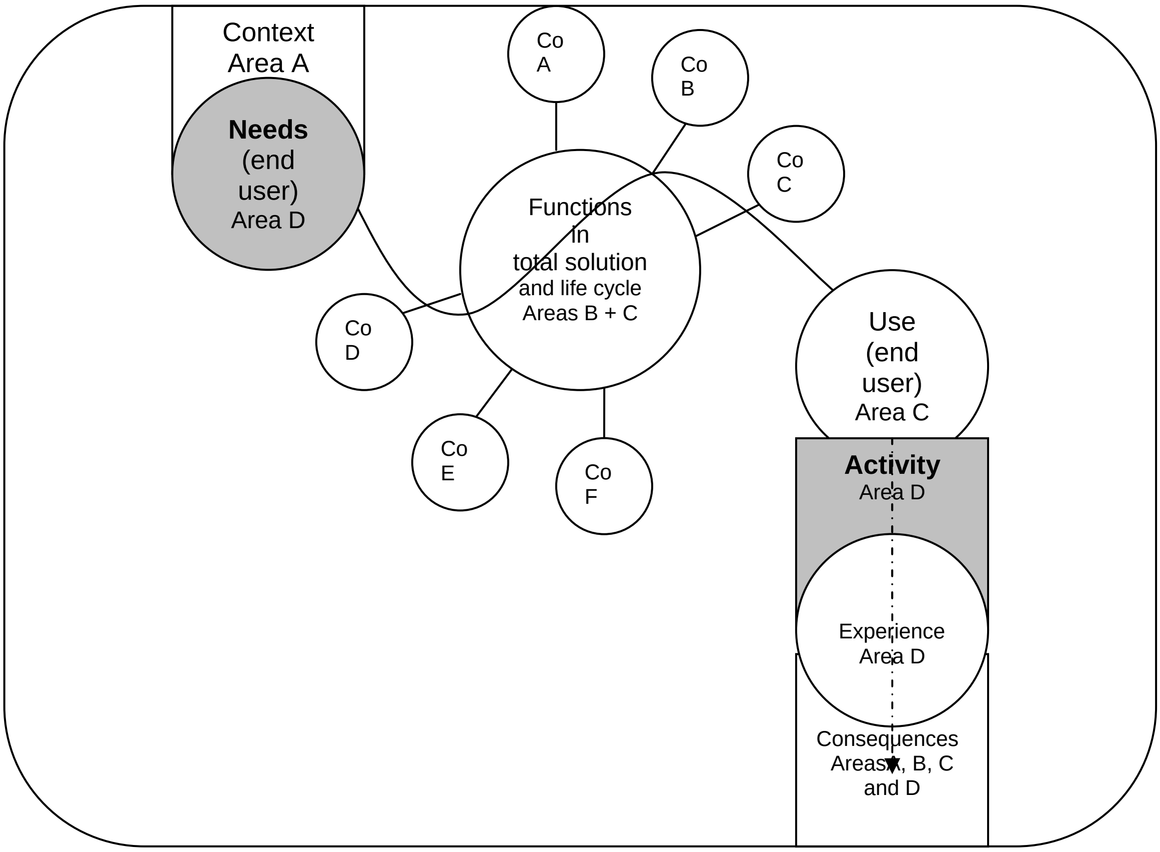


Figure 64 The figure shows how the companies co-operate towards the solution. However, the needs, the use and activity are the sources of the knowledge, and provide the conditions and feedback for new solutions.

It is important to understand the common end user as one who supplies the conditions for sustainable solutions, however, many companies have other businesses or organizations as their main customer so that it may therefore be the company in the front line of the system that is main responsible for the end-user focus (*Figure 64*).

9.3.3 Human Processes

Motivation

The individual motivation of the project and design team members is crucial for the actual performances and results from the development process. Individual performance and motivation were the objects of focus in the Lillehammer ’94 project, and were given high priority by the head of design. Specific communication tools were used to motivate stakeholders and supporters both internally in LOOC and externally. The pilot study mentioned the personal exceptional commitment in the working group. Through the task of scenario building and work methods “off site”, the participants felt they had strong ownership of the results (*Figure 65*).

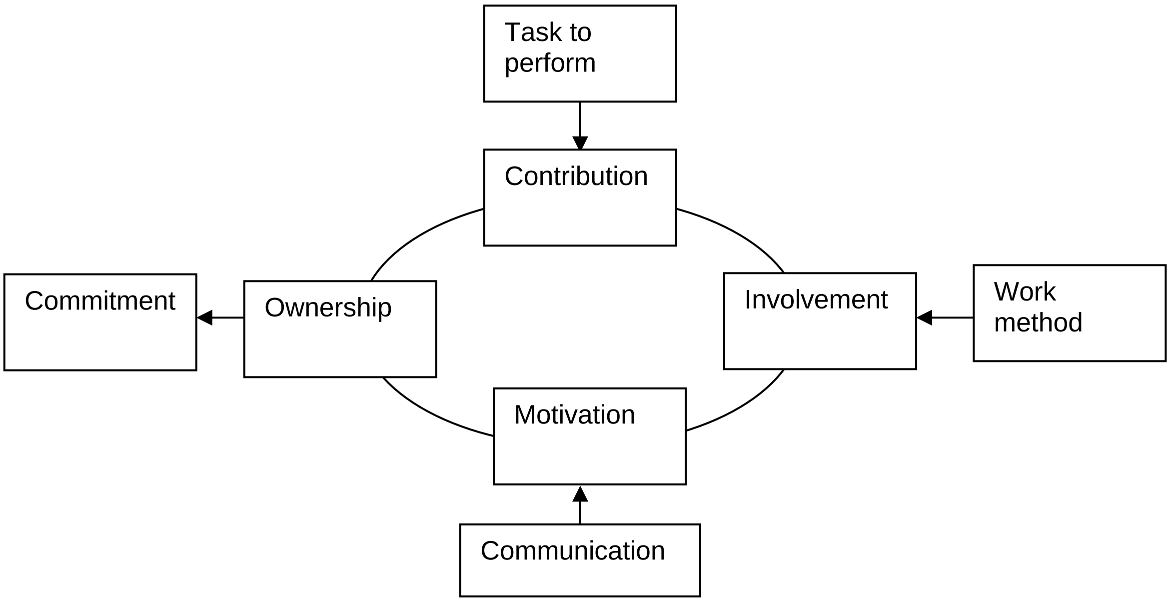


Figure 65 The figure shows a continuous connection between the four elements motivation, ownership, involvement and contribution. Commitment to a project seems to be influenced by the degree of ownership.

Communication for motivation

The thinking model and map may be used for communication and discussion between various parties in a radical design project. The map represents a manifold of expertise needed in these types of holistic project and may therefore increase the various stakeholders' feeling of ownership. The thinking map will function as inclusive and assist the process of assigning value to priorities. The thinking map can also be used to develop ideas and connections and to focus on personal contributions.

Setting the scene for different types of work

The different steps in the methodology need different work methods. It is important to secure motivation both on a professional and individual level through the right choice of work method. Inviting all the participants to contribute and creating settings for involvement were two aspects that were valued highly in the pilot and case studies.

This topic is an additional field of study. As mentioned above, Erik Lerdahl's thesis *Staging for Creative Collaboration in Design Teams* (2001) is highly relevant in this perspective.

9.3.4 Structure of the initial phases of the project

The initial phases consists here of eight steps and a phase for planning and initiating the project (Chapter 3.2). Each step is described in the sections below in connection with the models, figures, tables or other tools used to support the development and design process (**Error! Reference source not found.**).

The first steps, A, B, C, D and E, are of a strategic nature and are connected to the business profile and strategic issues: “functions, products, services and markets”, and “organization and environment relations” (Figure 18, Chapter 2.7.3). The strategic issue is relevant to the co-operation between companies in providing end users with a total solution. Steps F, G and H respond to the other phases and explore the “room” of new ideas, developing the ideas further, and prepare them for an evaluation in the last step. The continuing work on the selected design concept will be undertaken through the more traditional eco-design methodology in moving towards the final result.

Radical design framework milestone	**Focus**	**Tools/methods**	**Cross-references to models, figures, tables and illustrations**
Project planning, and initiation of project	Time schedule, combination of participants		*Figure 64*
A *Intro definition of aims*	User analyses of new product and system Human needs and activity	Human focus map Thinking model and map (Guiding graphs - quantitative evaluation)	*Model 6* *Model 5* *Figure 67* (*Table 28*)
B *Mapping and analysing*	Stakeholders and their deliverables to the system Environmental challenges	System map Thinking model and map Life cycle – mapping Functions related to ecological impact and possible solutions	*Figure 68* *Model 6* *Model 5*
C *Future scenario building – possible futures*	Society, long-term perspective	Scenario techniques	Figure 47 *Table 16* *Illustration 29*
D *Creating a vision – desired future*	System and product vision - qualitative sustainable principles	The thinking map Communication through the thinking model Visualisation	*Model 6* *Model 5* *Illustration 30* *Figure 69*
E *Strategies*	Long term and short term - qualitative sustainable guidelines	Short-term concepts towards long-term goals	*Model 6* *Model 5* *Figure 71* *Figure 70* *Table 26* Table 27
F *Design brief*	Specific area for new solution, problem or desire - qualitative sustainable guidelines and criteria	The thinking map	*Model 6* *Model 5* Figure 72 Illustration 31
G *The concept design process: Designing in light of future scenarios*	Human activity, satisfiers in the local context	DOS, Use-case analysis Human characters and prime movers in the different futures Parallel design,	*Table 22* *Illustration 29* *Illustration 30* *Illustration 16* Figure 28 Figure 30
H *Early concept evaluation, qualitative evaluation* *Selection of the most appropriate/promising design concept of new product and system solution*	Qualitative principles and guidelines	Evaluation and guiding questions Questioning the conceptual ideas based on the vision and strategic decisions	*Model 7* *Table 28*
Follow-up Product, (service), system design	Eco-design methodology used within the new radical design framework!		

Table 25 Structure of the methodological framework, initial phases from A to H.

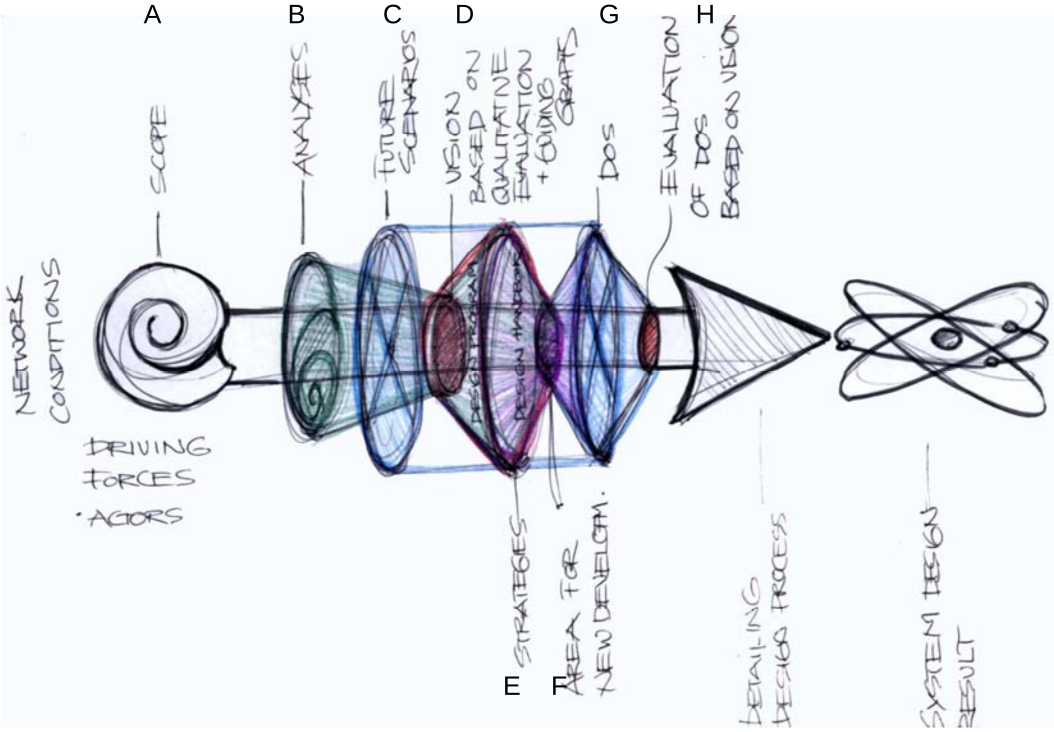


Illustration 28 The three-dimensional methodological approach, a visualization inspired by the pilot study (Wigum 2003)

9.4 The methodological framework for radical design, initial phase

A. Definition of aims

The aim of a factor 10 project depends on the context of the project (see target groups, 10.1.1). Clarifying the goals and aims of a project also contributes to the motivation within the development team and indicates what human, material and financial resources should support the project. As in a traditional project, the aims also determine to some degree the estimated time span, which should be realistic and appropriate. The methods chosen for the project must be relevant to the tasks, which complete the aims and goal of the project. The methods and focus in each step of the process will then contribute to the final goals. This is, however, basic project planning and management (Westhagen 1991).

Qualitative sustainable principles

Products and systems for sustainability will definitely have to possess the functions and characteristics of a successful product in general (Tonkinwise 2003). Each concept will need individual evaluation, and based on the principle from nature concerning diversity and local adaptation, different solutions will be appropriate for particular contexts. Nonetheless, this work concludes that there are some general sustainable principles (Chapters 2.2 and 2.3). The more specific guidelines are to a higher degree about forming the solution for the development task. Furthermore, the sustainable criteria are closely connected to the local and the specific situation, in addition to the detailing of the product and system chosen as the answer to the problem-solving process.

As discussed in Section 9.3, the starting point should be the end-user activities and needs.
To define the aims of the project it may be necessary to analyze the context; needs, problem, wishes and visions of the users in the actual situation (Chapter 3.3.3). This information can indicate the direction of the product aim. The initial ideas for the project might be redefined.

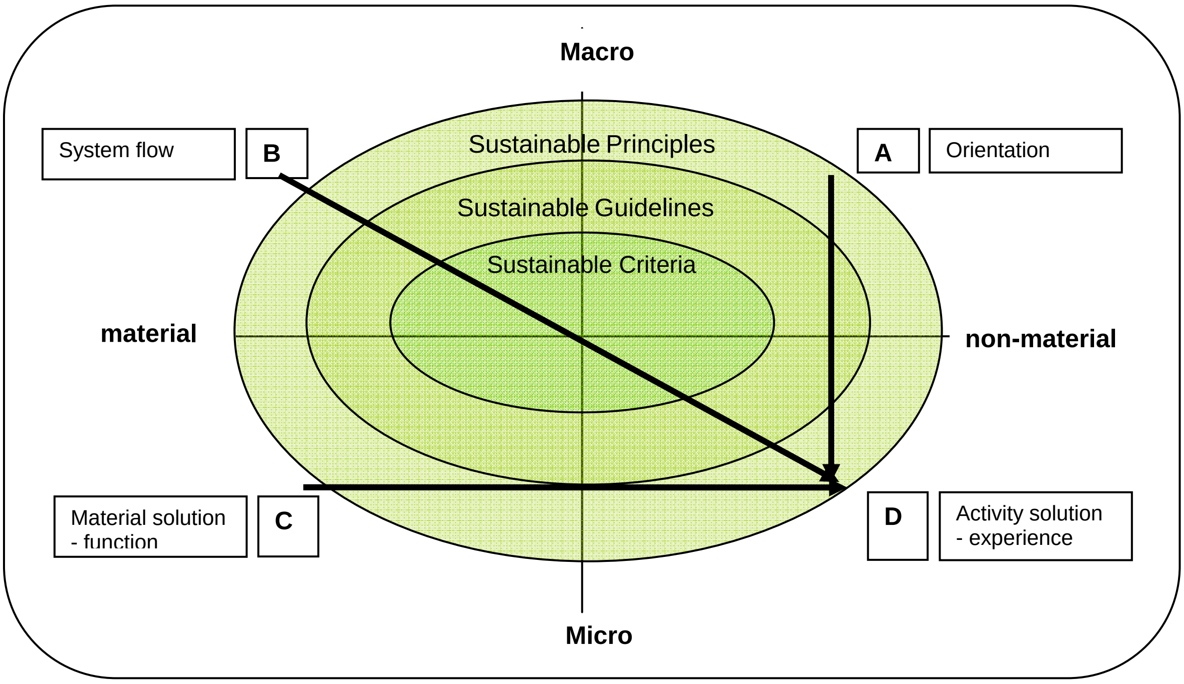


Figure 66 Area D is affected by all the surrounding areas and is influenced by the status in each of them.

The status in areas A, B, and C can give valuable information for understanding the status in Area D (*Figure 66),* which is the area of user (individual or group) experience, activity needs and meaning. The information gathered here can be structured in a more detailed overview, focusing on the user(s) (*Figure 67*).

Human focus

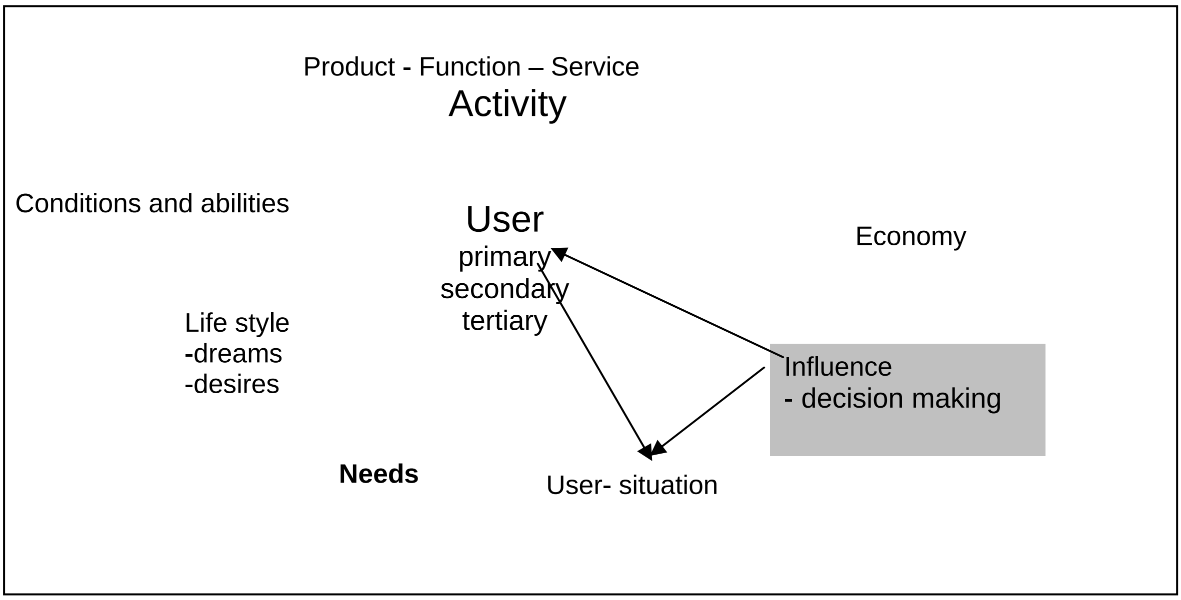


Figure 67 The figure shows that there are a number of factors related to the user or customer which are crucial for the new solution to be chosen and experienced as positive.

The needs, desires or functions are placed in both a local and global perspective, looking at the environmental impact connected with existing solutions, the history of the different product solutions and the future prime movers for new solutions, with the focus on human fundamental needs. This part of the introduction phase in the methodology is filled with input from many different fields of research and practical experiences. However, as Markides (1997) expresses: “The real innovation is to go beyond the obvious and to truly understand what is behind what people are saying, and create products or systems that satisfy these needs”. The Max-Neef matrix of fundamental needs (Chapter 2) also shows how the satisfiers are in four different states. Design for sustainability should promote design of synergic satisfiers (satisfying more than one need).

B. Material and logistic mapping and analyzing

In the pilot study examining drinking systems in Norway, several businesses but also organizations were stakeholders in the system. Each party represents important functions or specific services offered to the end -consumer or other businesses. The system becomes very complex, including the life cycle of the drinks, the functions of the stakeholders, the stakeholders themselves and the functions of the products (*Figure 68*). In addition to all this, the user needs also enter this picture (*Figure 67*). To simplify, visually the different “elements” may help the design team and others to see the connection between the different participants and their roles in the holistic picture.

System maps

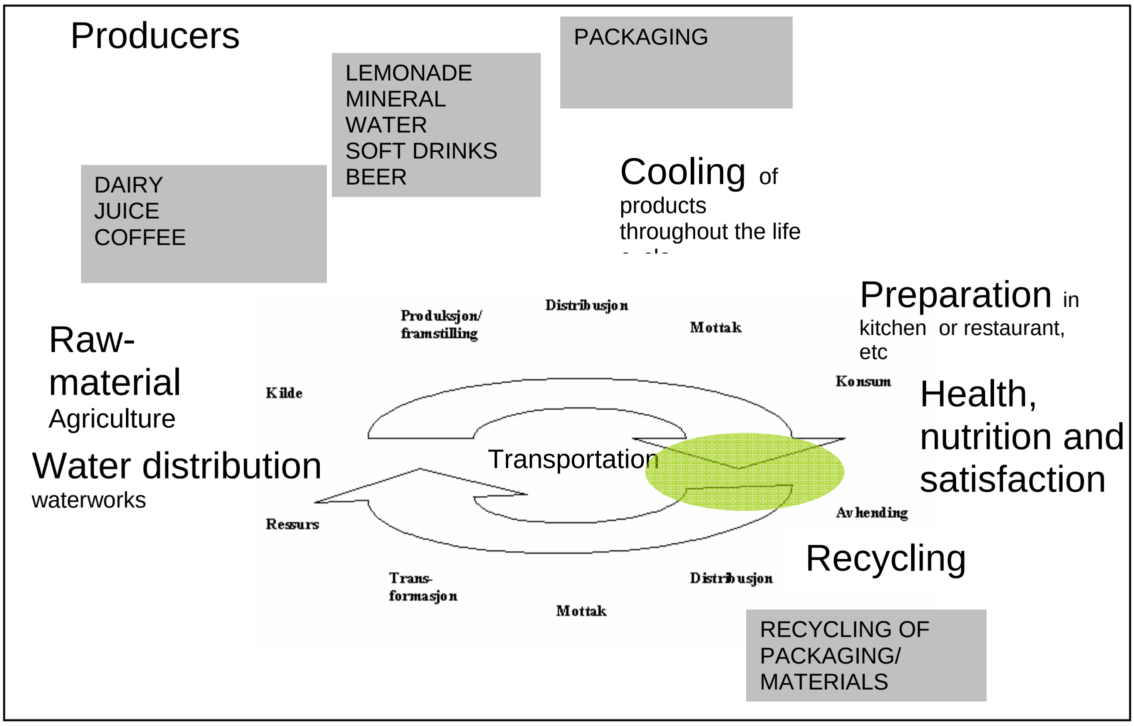


Figure 68 The green (circled) area points to the critical phase for the material resources where the customer/user impacts the further flow of the waste treatment. In this phase there are possibilities for communication between other actors and stakeholders in the system and the user. The grey (square) areas represent the delivery of products or other services from independent companies within the pilot study.

The system maps can have different characteristics depending on the complexity of the project and the people who make the maps. The map used as an example is a loose illustration of the system in the pilot study, and functions as an overview of the business participants and their contribution to the system of beverages.

A rough quantitative analysis may be interesting and important on this stage for revealing the most outstanding environmental impact causes.

Defining the sustainable principles

This step includes the business strategies and the core values of a company: Brand and identity, market and expectations from the customers the company views as interesting.

A systematic discussion through the thinking map (*Model 6*) will give wide input to the value priority, focus and definition of aims. The upper row captures the sustainable principles and involves the product and system solution in terms of main functions. This can be left open to some degree (product and concept functions), but depends on the main activity of the business or organization.

The worldview of the company and cultural profile is part of area A. Philosophical discussions might not naturally come under team work, but may be introduced through specific issues, such as cultural and social contribution channelled through the products and systems of the company and the collaborative efforts. Furthermore, how the material resources are evaluated in terms of chosen sources and how they are extracted (e.g. working conditions and evaluation of possible resources from the biosphere) are important. The motivation behind the production and development of products and systems should also be discussed.

C. Future scenario building – possible futures

The purpose of the scenario work dictates the method of the scenario building. This is again a field for specialists. However, different methods may be introduced on a simple work group level. The pilot study introduced the Delphie technique (Ringland 1998). A facilitator might be necessary or at least useful in this step.

In the pilot study the scenario building was undertaken with the aim of introducing a long-term perspective, system thinking and external factors which have influence on the choice of appropriate technology and the total solution. An important aspect in this work was the involvement of all participants in the work group on a non-hierarchic basis and located away from the daily site.

Different types of scenario building (Chapter 5.2.4) were good methods in the pilot projects for put the wide-ranging information together into an interaction with the problem definition to explore the most interesting possibilities and directions for future solutions. A combination of forecasting and backcasting was presented. Continuing with the statistics beyond the present and into the future in the actual graph is part of the forecasting approach. These results, however, are not likely to be illustrative of future development beyond introducing more unexpected interruptions in the development (Hanssen et al 2004). This approach presents a variation of *possible* developments and therefore different “climates” which might be the context for a new development.

Backcasting (Weaver 2000) is a possible tool that could be used with other procedures. This is one step in a methodological context and should not be mistaken as a methodology itself (Chapter 3.3.3). Backcasting means to describe the *ideal future* and how steps are taken backwards to the present to reach the desired results. This approach “envisions” future solutions and creates a more concrete vision for the project.

Possible or desired futures?
As Fussler and James say in their book *Driving Eco-innovation(1996)*:

”The central message of scenario planning is to avoid mental blind spots.”

The choice of method for scenario building is therefore closely related to the definition of the projects' aims. It is also debatable whether the project group has to work with future scenarios 40 years into the future or if this time perspective is less relevant. The long-term perspective is chosen in part to distance oneself from the present solutions and develop totally new ideas. In the pilot study, the future scenarios did not represent wished for or desired futures, but rather possible futures. This was an interesting process because new “independent” perspectives were brought into the discussion and the use of the Delphie-inspired technique brought contrasts to the debate on future development.

The scenarios can also be made more specific in terms of testing extreme developments and assumed consequences. The factor 10 concept is similar to this type of scenario.

In the thinking model, the future scenario building can be placed in area A (*Model 5*)as the description of the conditions in a society, where housing is a specific development task. Shown as an example below, the turbo-techno society (Table 16) was given as a future scenario and conditions to a group of students in the eco-design course in the spring of 2003. The students were invited to develop the scenario, however, they had to use the set of values which it already represented. Within this scenario the students should solve the design task: designing a product service system for the purchase of groceries in day-to-day life. The scenario gave information about the typical lifestyle of the user group, and the surrounding conditions. The four scenarios (Table 16) were distributed within five groups of students in this class. The groups came to an agreement in a plenary session on which scenario they wanted to work on.

When the students were given a pre-determined scenario, they did not experience the process of thinking in a long-term and broad perspective. Nor did the students feel like they had any ownership of this material. This was evaluated as a disadvantage for the later steps, however, as the students quickly managed to comprehend the content of the scenarios and use its characteristics further in the design process.

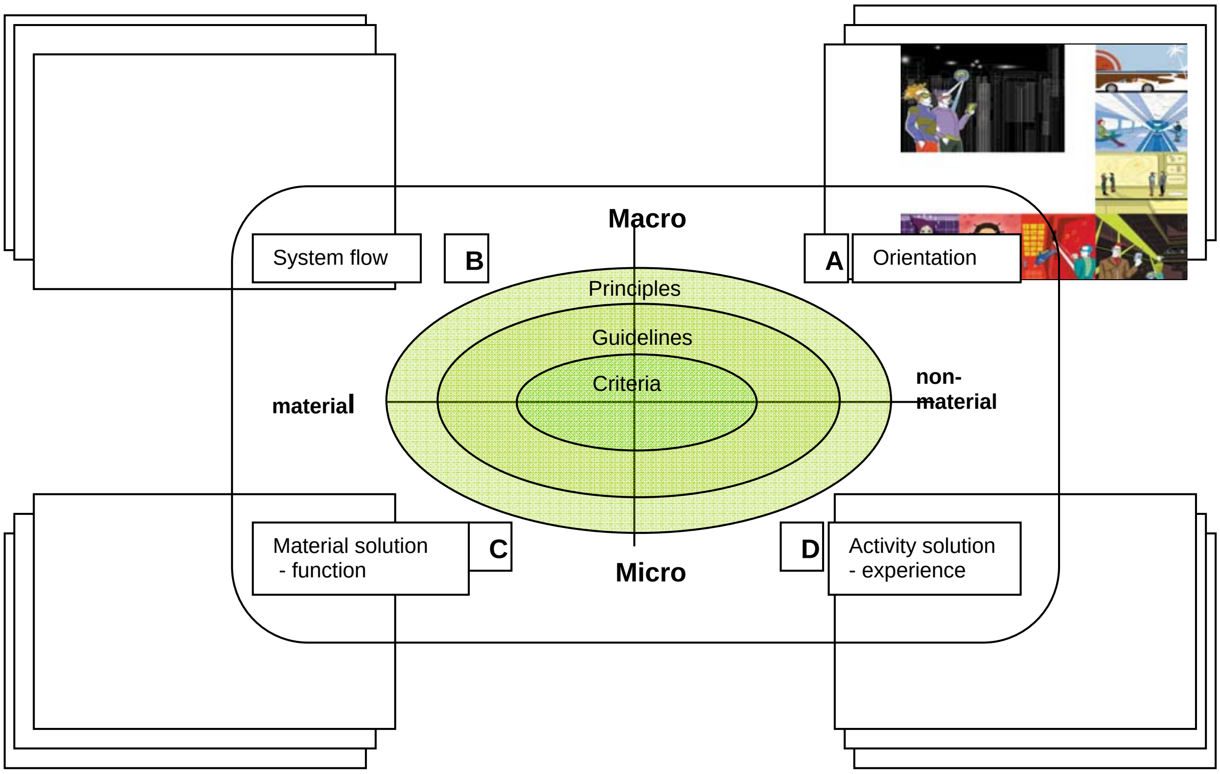


Illustration 29 The thinking model can function as an overview of decisions and information which are important for the final result. Here the model is used to communicate, superficially, the content of the orientation in area A. From the project: 3rd grade, Department of Product Design Engineering, spring 2003, Group 5: Lurås, Vindenes,Lilleng, Øyen, Elstad

The thinking model may function as a “systematizer” in terms of presenting the information and decisions analysed and produced. Idea generation and mapping of existing concepts can also be presented and communicated in this format.

In the pilot study, the scenario work was highly appreciated by the participants, and one of the participants described the process itself as the main goal. The scenarios seem to contribute just as much as a process, as in results, and should therefore be exercised with all the important stakeholders in the radical design project. However, the results from the scenarios must contribute to the ensuing process. The scenarios should be evaluated and compared to the previously established project definition of aims. This might provoke necessary changes to some of the goals and to the focus for the further work.

The scenarios should shed new light on the definition of aims and perhaps turn around the goals of the project.

D. Creating a vision – desired future

The previously described steps should feed this step by creating a vision for the new product and system. A vision can be placed on different levels and areas of decision making and development. The intention behind creating a vision is to give direction to the goals and to stretch the thinking above the concrete level and what can obviously be attained. This may introduce new solutions, but during the development process, the vision can bring a motivation and common feeling to the participants and connect the co-operating businesses on moving in the same direction ("guiding star").

The vision can be

- *on a political level*, for a society to develop in a particular direction, including defined values (dominating area A in model 6)
- *on a business level*, for defining the business values, strategic positioning (e.g. ecological co-operation), economic goals, organization culture or administrative perspectives (dominating areas A and B)
- *on a project level*, for co-operation between independent stakeholders. The vision may, for example, say something about a smaller project in a larger context (dominating areas A and B)
- *on a product level*, for image and direction for the designers and developers in their work with the development and design of a new product and system. The product or system vision can tell us something about the user experience in contact with the solution (dominating area D)

Placing the focus of the vision

The message of the vision should have a focus which *does not* determine the idea generation and final solution (*Figure 69*). Such perspectives belong to the goals and measurable results of the project.

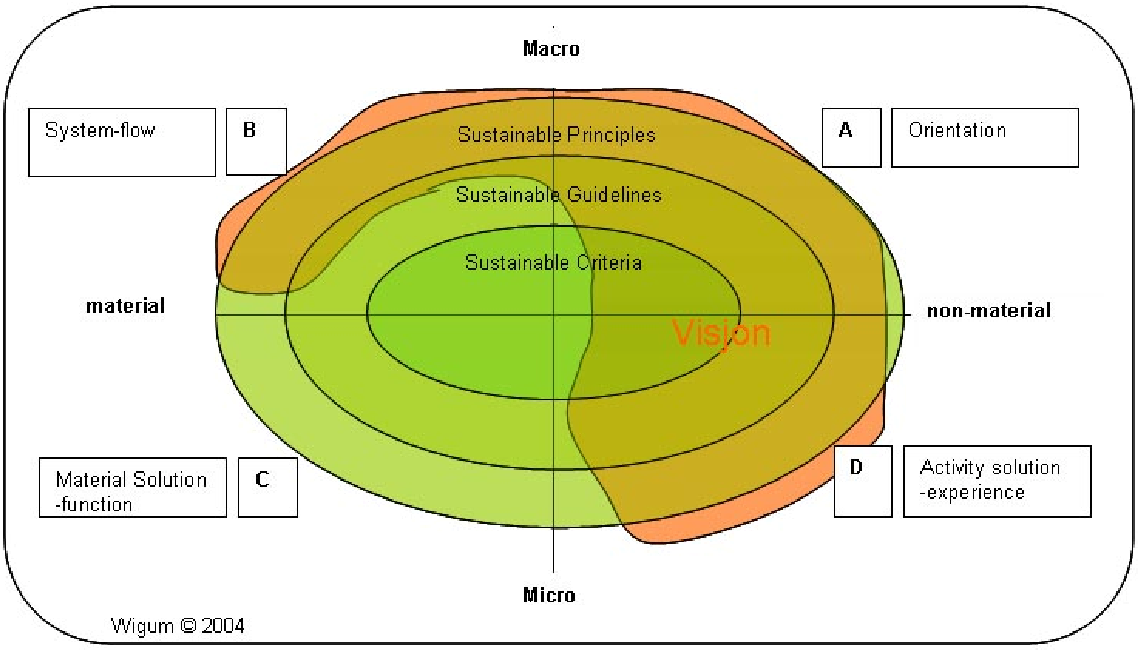


Figure 69 The thinking model and matrix can be used to discuss the values and priorities behind the vision. Area C should not be included in the vision since this area represents the area of concrete solutions.

Currently we have specific methods for developing the visions. Sometimes it seems that the vision is a personal contribution from the CEO. The reference case study, DSB, revealed a chief executive with clear ideas about the company vision. This vision was taken further by other directors; the director of human resources, the design director and the marketing director, to set up the detailed goals to transfer the main vision to the other areas in the company.

A company vision can be of a more abstract character; it will however, reflect the core values of the business and indicate a future direction.

A vision for a system or product must be more concrete in terms of the experiences anticipated in the encounter between the final solution and the users.

The vision of a system or product must not be in conflict with the vision of the company, but rather emerge from the core values of the business.

In the deep interviews, one of the respondents also mentioned the importance of defining values and a vision for *the project* itself. The vision would then say something about the wider perspective of the work and how the project was a smaller part of this. For the factor 10 concept, the wider perspective is globally based on terms of energy and resource use. The factor 10 project was a study within one sector (beverages), which is small, compared to other product and sector types. The team can also easily lose track in an “ocean” of numbers and information about detailed processes. A *project vision* could remind the participants about the meaning of the project.

The students in the eco-design course in the spring 2003 term related their product and system visions to the problem task concerning grocery shopping. Bearing their scenario study and the user context details in mind, some of the groups slightly changed the focus of the aim of their project. The focus of their visions then also changed, but still involved the perspective of the user experiences (*Illustration 30*). One of the groups changed their aim from grocery shopping to dining. Their vision for a new product and system: “The meal should give the users a moment of relief and a personal treat”

Visualisation of the vision
The vision for a system or product can be communicated and presented in different ways, through more abstract visualisation, metaphors, association techniques and so on (Lerdahl 2001) (Interview respondent A2).

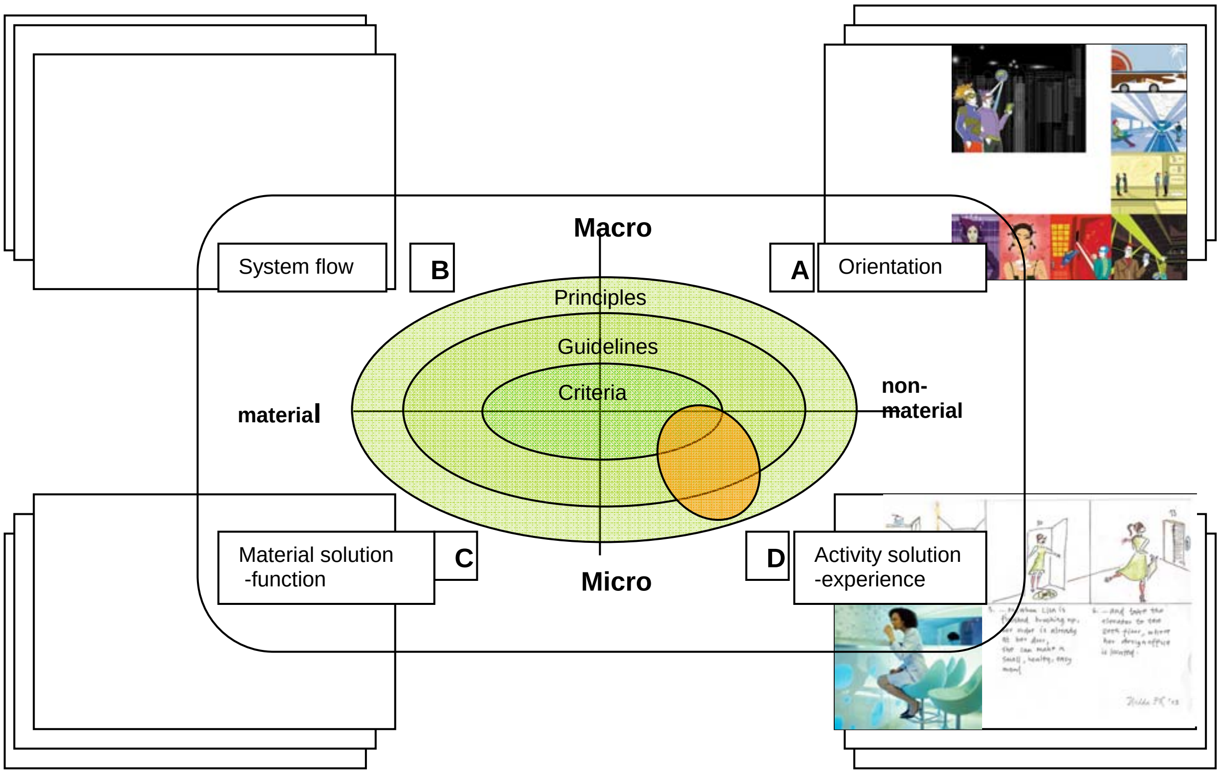


Illustration 30 The thinking model is used to illustrate the focus ("circular" element in area D) of the product and system vision in the students' project. The vision for product and system: "The meal shall give the users a moment of relief and a personal treat" From project: 3rd grade, Department of Product and Design Engineering, spring 2003, Group 5: Lurås, Vindenes,Lilleng, Øyen, Elstad

Flexibility in process
Focusing on the turbo-techno scenario, the students f chose to design a concept which gave their intended users a more relaxed contrast to the turbo-techno lifestyle that always seemed to run at high tempo (*Illustration 30*). In this project the students analyzed the human focus, user situation and context as part of the scenario work.

They defined the users as dwellers in a skyscraper containing both their private and professional activities and living. The food was then delivered to this location and centrally prepared on site.

E. Strategies

The product and system structures are introduced in this step and idea generation should begin to evaluate the potentials of the different solution strategies.

The sustainable guidelines based on the defined sustainable principles must be mapped and presented as part of the alternative strategies. Working with the map in the different squares, it should become clearer what strategies are interesting based on values from the vision. The solution as such will also need further detailing with respect to long-term goals and sustainable principles.

The concepts have to be placed in a short and long-term perspective
The different new design concepts will have different life spans for development. Similar to the "Backcasting method" (Figure 26), the different human behaviours, product, system and global development have to be visualized in an evolutionary or, if possible, revolutionary development.

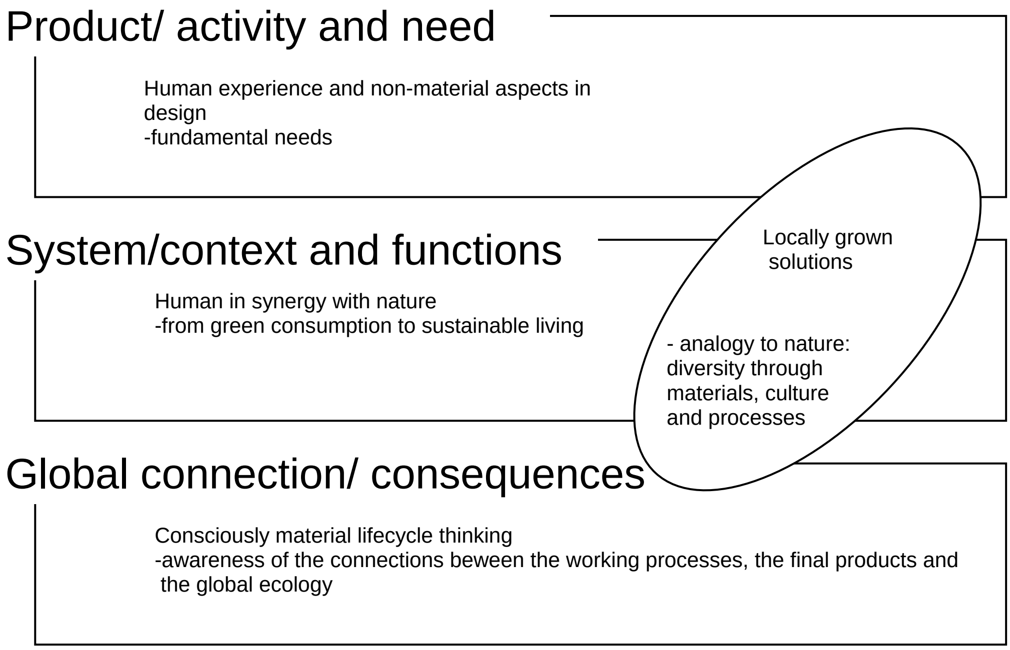


Figure 70 The sustainable principles are often strategies of a long-term nature: the product, the system and global connection related to the activity and need, context and functions, and finally the consequences of the solution both locally and globally.

The short and long-term goals may be related to the product, the system and the global level, and in terms of environmental impact (*Figure 70*). This may indicate a clearer stepwise approach of appropriate design of total concepts (*Table 26*). The consequences of a new solution must, in most cases, be evaluated over a certain period of time in actual use to see how sustainable the chosen strategy actually is.

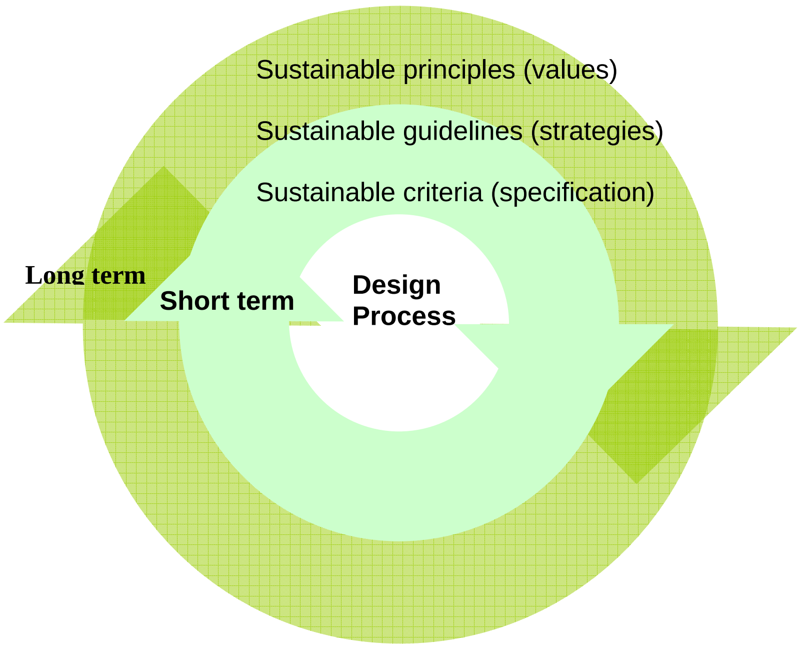


Figure 71 The design process should be undertaken in light of a long-term perspective, including the sustainable principles. The strategies are based on sustainable guidelines supporting these principles. For the short-term steps, the sustainable criteria must also be defined, such as specific use of chemicals, detailing in technology solutions, recycling mechanisms and aesthetic outcome.

Here the designer can be asked to visualize the type of concepts that are interesting and discussed in the team. The long-term and short-term goals can be illustrated through the discussions of principles, guidelines and criteria in the areas of the thinking map (*Figure 71*) (*Model 6*).
When working on this step, decisions should be made on how the needs and activities are defined and furthermore how they are supported by either a product or service, or only by a service provided, for example, by a human-based system (Appendix X).

Focus: **(here from pilot study)** **Change in attitudes** **Closing loops**	**Short-term perspective 2005 Solution strategies**	**Long-term perspective 2030 Goals (in scenario)**	**Total environmental impact**
Product Reverse vending machines and recycling containers. Two-way communication between users and system stakeholders through product level.	The meeting between user and machine. Interface contains information about the system which the machine is a part of, locally and globally.	Recycling of all materials is a matter of course in households. The recycling systems are integrated in homes or are done in other convenient ways. (see DOscenario	In short-term the new reverse vending machines will become more resource consuming because of the technology and digital display. This should in the long-term be paid back because of the function of the products.
System/ service Material cycles Fulfilment of functions in order to close the resource cycles and support the encounter between the user and the user activity and needs.	Beverages and packaging material cycles: Reuse and recycling can be communicated and visualized through video shots of environmental savings achieved by handing in and sorting used material.	All type of foodstuff packaging is recycled or reused. Many variants of packaging are part of a separate trade system which motivates to clean sorting. It is a natural part of the daily routine to return all the material resources to the system after use.	Today 97.5 % of the deposit bottles are returned to the system after use. This is, however, only about 2% of the total food-stuff packaging. Here is a large potential for recycling of materials based on knowledge from this success.
Global connection Local understanding of international agreements and trade	If the users of the products and systems see their own contribution in specific connection to other common goods and environmental benefits, it may be meaningful and natural to act.	International trade of all kinds of merchandise demands a flexible and user-friendly recycling system. (E.g. from the manifold society, table 20)	International agreements like the Kyoto agreement include goals which everyone should work towards, rather than trying to escape from them, e.g. via the purchase of CO_2 equivalents.

Table 26 Short-term concepts leading to long-term goals should result in people moving in the direction of sustainable development. The examples presented in this table are taken from the final factor 10 pilot-study report (Hanssen et al. 2004).

The design programme
In the Lillehammer ’94 case study, the design programme gave clear strategies for the image profile, material choices for 3-D objects and architectural preferences. A choice of values also indicated the long-term perspective of the architectural buildings, reuse and after use. The licensee products were also described as long lasting and have other qualities than just being part of a passing fad and commercial promotion of the Lillehammer ’94 event.

In a factor 10 perspective, the long-term goals of new solutions may be discussed in terms of a slow shift in behaviour patterns and a slow shift in material or energy resources and so on. This is probably more relevant for municipally run projects. On the other hand, companies may also develop such stepwise long-term thinking through legislative regulation, decrease in certain resources and so on. The factor 10 concept is based on these types of issue, which are mainly represented through statistical figures and prognoses.

A design programme for a factor 10 development in a company cluster or trans-organizational co-operation could include elements which are based on particular sustainable principles and the guidelines or strategies described as a direction for practical approaches.

When it comes to energy consumption and evaluation of new concepts, a matrix including the orientation (here focused on social issues in area A) and the ecological environment (here the system flow of energy in area B) would for example include:[13]

AREA / Energy consumption	A Orientation	B System flow
Sustainable principles	1. Energy concerns need to be incorporated more directly into the political decision-making process through such mechanisms as improved environmental assessment 2. Increase public involvement in the topic of energy consumption	1. Promote integrated life-cycle management and close material cycles in the chain of raw materials (production process, product, waste, emissions) 2. Energy conservation and increase in efficiency and utilization of renewable energy resources
Sustainable guidelines	1. Base energy policy on resource efficiency 2. Declare energy efficiency standards for appliances or products 3. Consider energy de-regulation and privatization. 3. Organize public information desks and community projects for sensible energy consumption	1. Energy conservation and increase in efficiency and utilization of renewable energy 2. Energy Cascading: Energy cascading uses residual heat in liquids or steam from a primary process to provide heating or cooling for a later process. For example, excess steam from a power plant or refinery may be used in a food processing plant or greenhouse.
Sustainable criteria	1. Average annual residential electricity consumption 2. Cost of different energy sources for households 3. Number of citizens participating in community projects such as ENØK (alternative energy use and energy saving)	1. Total amount of energy use 2. Type of energy source 3. Amount of self generated energy 4. Amount of co-generated energy

Table 27 Example of specification of sustainable principles, guidelines and criteria defined for areas A and B for evaluation of early conceptual solutions for energy consumption, filled out and tested by Martina Keitsch (Wigum, Keitsch 2003).

F. Design brief: the description and planning of the design process

The design handbook
In the Olympic '94 design project the design programme was followed by a design manual or design handbook with clearer details, and in this specific case, the graphic elements which constituted the total visual profile. Different design handbooks were made especially for the 3-D objects and architecture but they were all based on the direction laid out in the design programme. The design handbooks were seen as design briefs for the Lillehammer '94 projects.

[13] See also: http://www.globalreporting.org/guidelines/protocols/EnergyProtocol.pdf

For a radical design project, the design brief should be based on a specific user activity within a wider perspective: the orientation (results from scenario building), the local setting, the vision of the concept and accompanying strategies.

The history, the present and the future
At this stage, the design brief differs from a traditional design brief as it contains the design process for new concepts in total, not a single product in a given setting (Figure 72). The problem definition is wider as it is an activity or need instead of a concrete product or system. Nevertheless, the result of the process should be a system and products supporting a need and activity in a sustainable way, corresponding to the factor x concept in a long-term perspective.

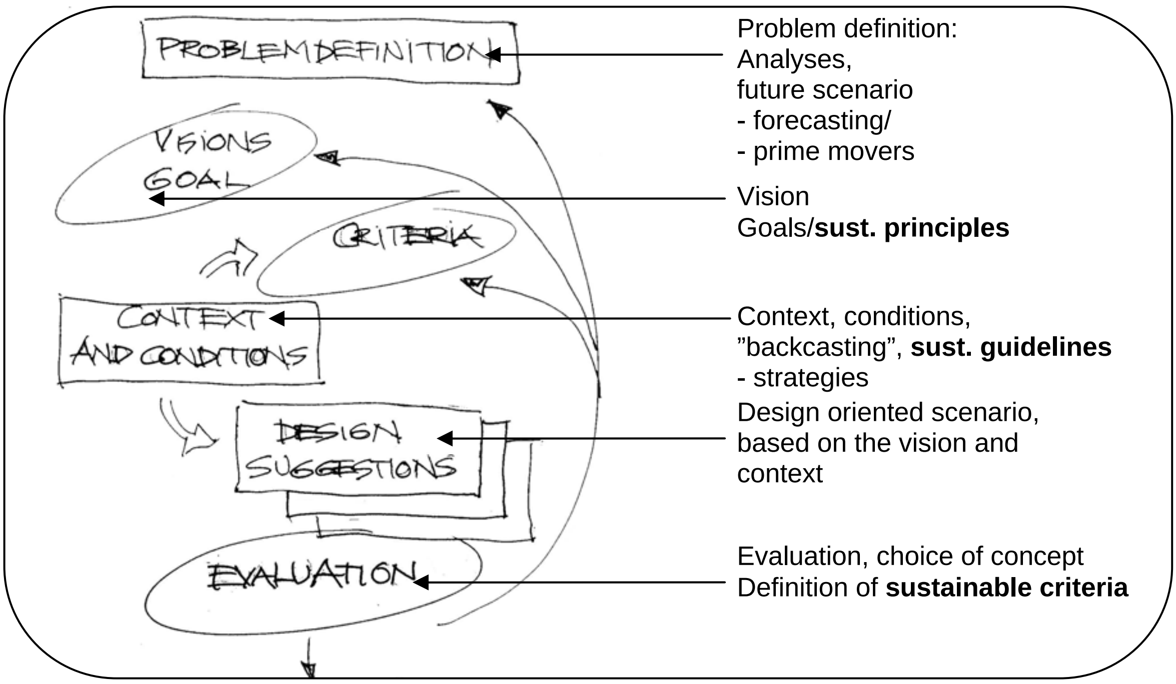


Figure 72. The design brief should include sustainable principles, the selected sustainable guidelines and a rich problem and definition of aims based on need and activity (figure based on Wikstrøm 1994).

The design brief differs from the traditional brief with respect to detail criteria that cannot be introduced until the broader concept solution is chosen. This might differ to some degree, depending on the starting point of the project, however, the details may be of great importance to the overall principles, and should therefore not be pinpointed before the outlines of the solution are designed and evaluated.

The design brief can also introduce themes that characterize the desired solutions based on the strategies (sustainable, principles and guidelines). Lillehammer ’94 had three themes (Chapter 7.3.6), which supported the vision and gave more concrete inspiration to the designers in their process.

For the student projects in the eco-design course of the spring in 2003, their problem definition at this stage was limited to eating and the purchase of a meal (group 5), and the needs emerging in the concurrent context.

The project team and the participants:
The co-operation might involve specialists in different stages and steps of the process, for example a biologist, anthropologist, theologian, environmentalist or politician. The typical knowledge within design, marketing, production and the environment should also be part of the network. The members of the design team at this stage might be different from the previous steps.

The core team should not consist of more than six people. This depends, however, on the number of co-operating stakeholders. The thinking map (*Model 6*) can be used systematically in the design brief to evaluate the need for different competencies in the project. It may also be used to discuss the individual professional specialties and also work interests within the team. The thinking map was used in the test workshop to discuss the need for specialized people in a project to support the areas in the map that seem important for further development of the chosen strategy. However only one-third of the participants found this very useful, the remaining two-thirds found it somewhat useful.

Participants with different professional profiles will have different roles in a radical design project and will use different methods related to their profession and dedicated task in the project. It might be that these methods, such as within economics, will have to be evaluated according to environmental issues, as the traditional design methods have been evaluated in this thesis.

Can we make it as simple as a deciduous tree?
As a reminder in the design brief, the sustainable principles, guidelines and criteria within the four areas of the thinking model and map may be described by the metaphor of a tree.

Illustration 31 A tree can be used as a metaphor and reminder of product and system qualities which can be presented in the design brief (photo from Thorsen et al. 2002).

Micro-level

Area D experiences, activity solution:
The tree contributes to local aesthetic experiences and diversity in several areas, for example through the cycle of the seasons. It can also provide shade; protecting from the sun wind and rain.

Area C material solution:

- Principles: The tree consists of materials which are defined for different functions and longevity. It supports numerous needs of other creatures, in addition to its own existence. Trees have functions that are vital to the local area and are part of the “global green lung”.

- Guidelines: The stem, branches and leaves are connected through defined structures based on individual tasks and functions, rooted in local conditions.
- Criteria: The structure of the stem is a composite supporting the stem's carrying capacity and bringing water from the ground to the leaves. The branches have their shape and ability to point and raise the leaves towards the sun. The leaves have their special inner chlorophyll mechanisms to execute photosynthesis. Their short life of one season also demands that they are a material that composts in a short amount of time.

Macro-level

Area A Orientation: Social and cultural

The tree is home to many creatures. Trees are important elements in a cultural landscape and affect the behaviour of people as well as animals.

Area B System level:

The tree contributes in a global perspective as it produces oxygen, processes CO2, supports water cycles and local carbon chains and other vital substances.

Each area should be discussed according to principles, guidelines and criteria on a deeper level.

G. The design process: Designing in light of future scenarios

Human characters and prime movers in the different future scenarios, parallel design

In the pilot study problem areas and related strategies were randomly chosen and experimentally seen in light of the different future scenarios (Chapter 5.2.4). The solution strategies include different definite products and systems which support functions, activities and needs.

Ideas may be generated by means of design oriented scenarios (Chapter 3.3.3, Chapter 4.2.4), based on the framework from the relevant issues in the future scenarios (Table 16). However, the design oriented scenarios need a more systematic design approach to become more locally related and holistic, also on a system level.

Table 20 (Chapter 5.2.4) explores the possibilities of closing the material cycles from household waste by addressing the private kitchen solutions and end-consumer activities. This is also connected with the recycling system and finally with the context for the solution. What are the economic perspectives and what is the valued priority for solutions in the actual user group or society?

By using this method, a new technology can roughly be seen in interconnection with other products or systems that are of importance to the final result.

Parallel design is a term also used for the process of many designers designing different concepts at the same time, while employing the same problem definition. The word parallel design here refers to actually designing a system and its products in parallel, however, not independently of one another, but in close relationship to each other. This process can be integrated in the methodology for the design oriented scenario. In Chapter 8.5.2,Table 22, shows a generalized table of parallel designing where relevant scenarios can present a context for new concepts containing harmonized systems, products and specific elements.

Design oriented scenario technique combined with future scenarios

As the local material solution (area C)in the eco-design course, in the spring of 2003, group 5 developed , a dining section in the skyscraper which was defined as the physical context of their intended users (skyscraper dwellers) (part of area B). The dining area contains a vending machine for freshly made food. The interaction with the machine was based on personal recognition by placing a hand on an interactive display (area C). The origin of the food and the logistics to the skyscraper and finally to the vending machine were described in a flow diagram (area B) (*Illustration 32*).

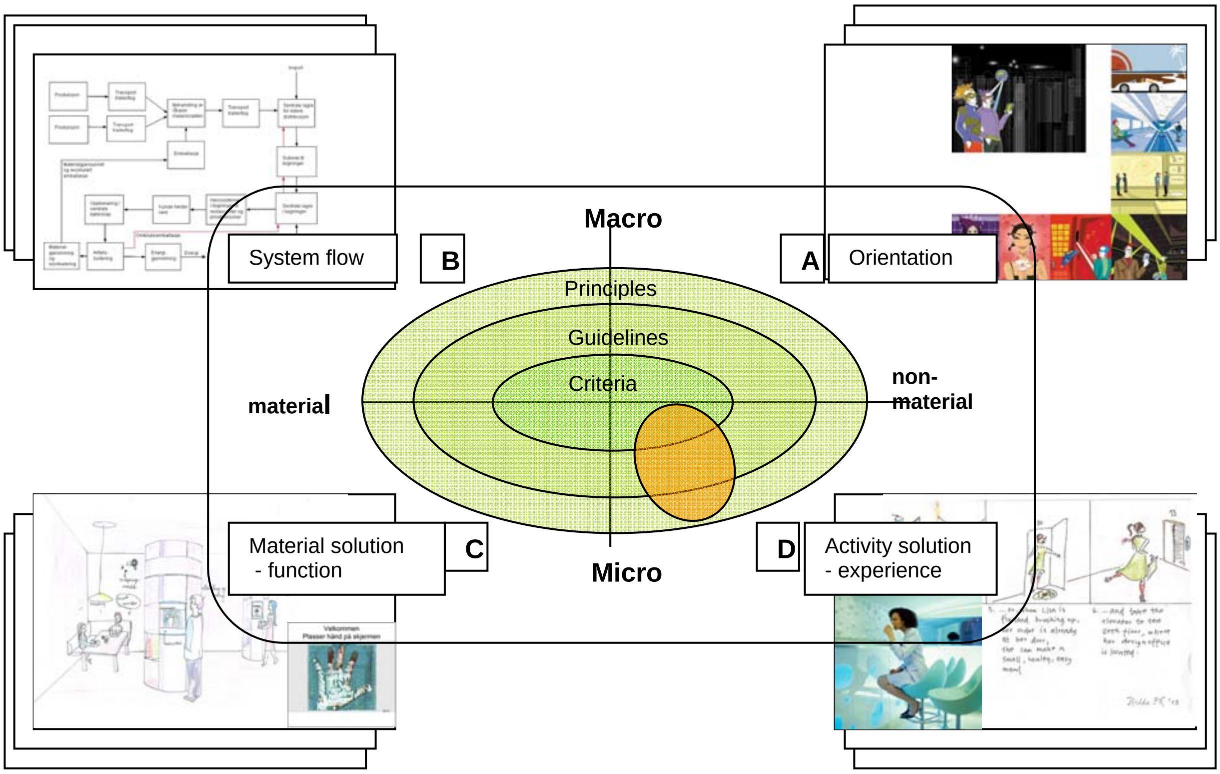


Illustration 32 The thinking model is used to present the design oriented scenario of group 5, and the turbo techno climate. From project: 3rd grade, Department of Product Design Engineering, spring 2003, group 5: Lurås, Vindenes,Lilleng, Øyen, Elstad

The other four student groups were given other future scenarios (Table 16) and worked therefore on the methodological steps in totally different "climates" or orientations (area A). The following student group was given the scenario of the isolation society. This is a scenario where the conditions are based on all kinds of security, motivated in general by fear.

Group 1 chose the solution strategy that went against the grain of the prime movers in their future scenario, the "isolation society". They wanted to create a social meeting area for people in the neighbourhood through the activity of shopping (Illustration 33). The system and product concept should invite people to come out of their private spheres and buy their groceries, instead of having a transport service coming to the house of customers to deliver them their food (area A).
The vision of their concept: "To create a social and welcoming contrast outside of the private sphere"

The concept included a personal assistant welcoming you to the grocery store (area D) who could give you advice and information concerning the products in the store, if requested.

The products and food in the store were all marked with riff tags r to provide information from the total life cycle of the products, including origin and content. The profile of the store would be characterized by organic labelled products and "fair-trade" brands (area B). The store itself was presented as light and open. Some of the social attractions were a cafeteria and a cookery library (area C).

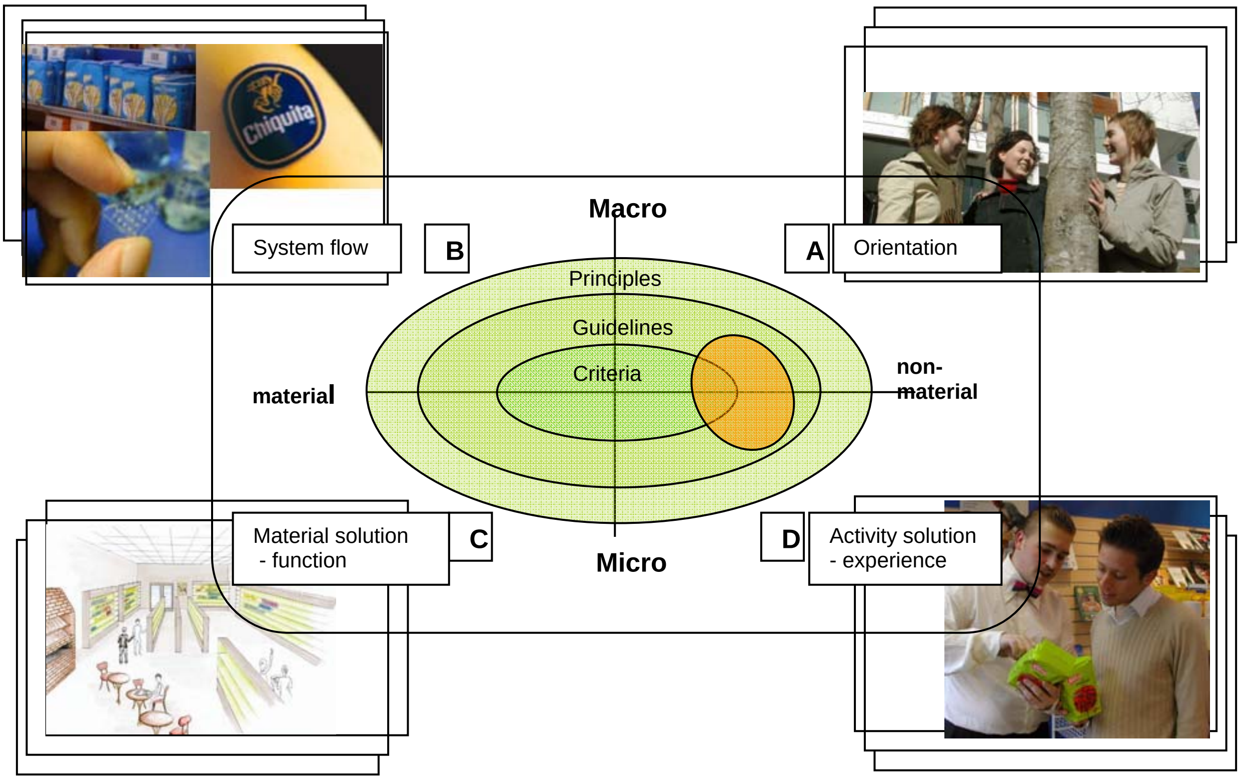


Illustration 33 The isolation society required a different type of concept solution from the design/industrial ecology students. Social context and secure food were main goals for the concept. From project: 3rd grade, Department of Product Design Engineering, spring of 2003, group 1: R. Dehli, Nesbakken, Lee Mei Chean, O. Svensen, G. Pedersen, Breen.

Group 1 used Morelli's keys and use case study to find the shopping activity sequences and the encounters between the shopper and functions in the store (Chapter 3.4.2, *Figure 30*). The students introduced their own additional element –the type of atmosphere that was wanted in connection with each of the user activity sequences in the total concept (*Figure 30*).

H. Early concept qualitative evaluation and discussion

Evaluation and guiding questions
The design process and idea generation should reveal different concepts based on the same conditions (scenarios, vision and strategies). The sketches of these concepts then need to be evaluated before one solution is selected for further development.

The different facets of the concepts can be evaluated through questions asked and answered (*Model 7*). The answers are compared with the vision and defined values which are chosen in step C, but also in comparison to the concrete analyses and discussions in step A of the framework.

	A Orientation	B System flow	C Material solution	D Activity and experience solution
Sustainable principles	•What is the intention of the concept? •How is it related to society?	•System perspectives: How is the flow sustainable?	•Does the main function answer the specific situation of the intended user?	•Does the total solution seem meaningful to the intended user?
Sustainable guidelines	•How is the acceptance presumed according to social, cultural and spiritual context? •Ethical values: How are the perspectives of people involved represented, and how are they empowered within the new concept?	•How are the local conditions integrated into the concept? •Can the use of natural resources, as well as energy and output of emissions be justified?	•Is the solution appropriate to the users needs? •Does the solution open for sustainable living?	•Are the needs and desires fundamental or substitutes?
Sustainable criteria	•How are daily routine and behaviour affected? How does the concept involve traditions, rituals or sub-cultural specialities?	•What is the basic thinking in creating the cycles of the resources?	•Are aesthetics, technology and materials expressed in an appropriate way?	•How do the final experiences of the user stimulate senses and satisfy fundamental needs?

Model 7 The evaluation map. This matrix is filled with questions in each square, turning the concept ideas back to the vision and the previously stated values.

The student concepts were discussed and evaluated in a plenary session on the final presentation, and also evaluated by the students themselves during the design process. Critical aspects were revealed in all of the student concepts. The next step would be to consider the feedback and see what changes could be implemented to improve the idea. The students' projects emerged from the questions they had to consider as they progressed through the process (Chapter 8.9). They were not given the thinking map and model (at the time they were still under development). However, they were guided in the direction of thinking in the different areas represented in the model.

The final report in the pilot study presents some evaluations considering which future scenario of the four is the most feasible for supporting sustainable solutions. The evaluation was undertaken by the project leader and in his perspective, the diverse society based on cultural and political openness was best prepared for radical changes and shifts in mentality. Similar to most qualitative evaluations, however, this can only be seen as a discussion and not a final conclusion.

The Lillehammer '94 design concepts for the design programme were based on evaluation through internal discussions in the design team, but also through open presentations where the early concepts were shown to the entire LOOC organization for immediate feedback.

The quantitative guiding graphs, of resources available
It may also be highly important to introduce some quantitative evaluations, or numbers in general that can evaluate choices for material and energy sources, concerning how much is available on a global and local scale. Furthermore, what production processes and treatment are available at the moment in the specific situation (this may also be rather quantitative information).

This information will be important for further specification, for the process of defining sustainable criteria for the chosen solution concept and for factor 10 measurements. A table can show the specific local condition (local compass) and the global relations (*Table 28*).

Concept for evaluation:	Local compass (Area C)	Global relation (Area B)
Site and conditions for concept:	Site specific description Demographics Material resources Material treatment Energy Climate Economy	Global interest Material resources Material treatment Energy Climate Economy
System and product:	Specification	Specification

Table 28 The quantitative guiding graphs will indicate what material and resource sources are actually available locally, but also how much is available in a global perspective.

The next procedure in the development of the selected product and system concept is further design detailing and preparation for realization. The traditional (eco)design tools are useful in these phases, however, decisions *must* be coordinated with the design brief that contains the discussions and value profile represented in the vision, followed up by the sustainable principles, guidelines and criteria strategies from all the four areas (A, B, C and D) for the new and intended product and system design.

9.5. Closing remarks based on the results from tests of the models

The initial steps' methodological frameworks presented in this chapter are supported to a high degree by the thinking model, the thinking map and the evaluation map.

All these tools were tested in a workshop with participants from the natural sciences, social sciences, and humanities as well as from the design and product development (engineers) professions. Overall, 14 people attended the entire workshop and answered a questionnaire, sent to the participants by e-mail a few days later. All participants answered and returned the survey.

As general feed back, the participants (surveys in Appendix XI (in Norwegian)) were asked to point out the strength and weaknesses they saw in the tools. There was high agreement on assessing the models as good tools for discussion (11/14) and communication (7/14). Furthermore, eight of the 14 participants experienced the tools as “door openers” for various viewpoints and disciplines and six participants understood the models as inclusive for a variety of values. It was especially commented that the thinking model defined visual spaces for the non-material aspects as much as for the material. This was seen as very positive.

Half of the participants found the thinking model and map complicated to comprehend, however the thinking model was appreciated by many of the participants. Similarly, half of the group found the content of the tools unclear and more than half (8/14) saw it as a drawback that the process of using the tools needed to be facilitated to be understood and supportive in practice.

For their very first impression of the tools the participants ticked a combination of “interesting” (12/14) and “complicated” (10/14).

None of the participants evaluated the models on first impression as “banal”, “exhausting” or “fun”. Descriptions with 1-3 crossings, where “Enlightening”, “Frustrating”, “Clear”, “Useful”, “Intuitive”, “High degree of news”, and “Low degree of news”.

This workshop does not represent the authentic working context, neither for the tools nor for what the framework is meant to be. Nonetheless, it was interesting to see that eight of 14 participants found the model *very useful* for directing the focus of their vision (step D), as defined in the workshop, and six found the same aspect as *somewhat useful.* No participant found this step useless. This was one of the most important steps in the new framework for radical design projects.

The thinking map most likely needs to be further cultivated in the squares and layers. By developing the map more clearly, the need for facilitation might decrease and the tool might become more efficient.

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10.0 Summary and discussion

This chapter will give a brief summary of the main content of the thesis, beginning with the motivation for the thesis and moving on to the aims, objectives and research questions. These were developed within a research approach based on the phenomenological view of how to create scientific knowledge involving constant change and interrelations between subject and object. This thesis is presented as a theoretical, methodological and practical contribution to the field of design for sustainability. A brief evaluation examines some of the strengths and weaknesses of the thesis and the chapter ends with recommendations for further research.

10.1 Summary of thesis

10.1.1 Motivation for the work and the general contribution to the field

It is a paradox to be trained as a designer and then discuss how a product can be designed and produced so well that people will not need, or not even want so many products and things because they are very happy and satisfied with what they already have. However, this thesis is about creating good and meaningful settings and surroundings which stimulate daily life through an interesting system and products; solutions developed on sustainable principles, guidelines and criteria found in nature, philosophers' minds and children's world perspectives.

The lack of design methodology which lifts the design tasks into the conceptual phases of development of new systems and products was something I saw as a problematic shortcoming when it came to actually creating change through industrial design. The factor 10 concept was inspiring as a global and long-term view on the overall material and energy issue. The concept evaluates the environmental impact *per capita* and relates the issues of sustainability to individual human consumption. This perspective provokes questions on the quality of life and whether or not the material standard supports this. The circle was closed.

Current eco-design methodology is focused to a high degree on the redesign of existing objects in a business. With a few exceptions, other methodologies for sustainable innovation on the product and system level are not connected to a specific location or business context. The factor 10 design methodologies are also dominated by a strong technological focus or a rather theoretical approach to the challenge. The clear challenge is to balance the dominating physical standards, quantitative material and economic measurements with humanistic issues, such as quality of life, intention and meaning of new development.

This thesis has focused on the strategic nature of design, and how a chosen set of qualitative and rather non-material values (user experiences, social and cultural intentions, ecological principles, and so on) can guide the design process and promote sustainable products and systems. This research has consciously ignored the traditional borders defining an industrial design process and the designer's aim. One contribution from this thesis is that it encourages designing to start at the business strategic level in companies and organizations. The design process does not only mean deciding the physical and organizational structures and attributes of the new product, service and system. It starts with a wider context of human needs, future scenarios and business relations for holistic solutions. These perspectives are transferred to a vision and to design strategies for the new solution which carefully relate to the business profile and goals. Long-term strategies for the business or network of actors (businesses, organizations, and researchers) should support the short–term steps in a new development and vice versa. However, this is a never-ending story. Based on numerous experiences and ideas from other practitioners and researchers, this thesis is an additional initiative for fusion of qualitative and quantitative knowledge of both a material and non-material nature in design for sustainability.

10.1.2 Research perspective

Phenomenology describes a view of epistemology (creation of knowledge) as an act depending on the interrelation between the subject and the object. Knowledge is developed as an understanding of connections which are constantly evolving. The designer is a part of a process which is a constant interplay between subject t(the designer or other people involved) and object (what is to be designed). Designing is about change through creation of new solutions. The research methods, however, are not typical for the phenomenological view, but are chosen to explore the practical approach in the design process, as well as the theoretical and conceptual understanding behind sustainability and its connection to the designing of products and systems.

The thesis has been based on a *flexible research design*, which implies that the research questions have evolved through the initial phases of the research and fine-tuned after a completed pilot study. This is the structure of this research. Initially, the focus was specifically on product service systems (PSS) and how sustainable values could be represented in these concepts. Finally, the research questions were tuned in a more general direction concerning the human focus as a starting point in system design, the long-term perspective, and the integration and evaluation of sustainable principles, guidelines and design criteria in early product concepts.

The pilot study involved several Norwegian companies within the systems of beverage production and delivery in Norway (Chapter 4). The factor 10 concept was introduced as a focus and motivation for the pilot study. Environmental impact mapping and discussions on new sustainable solutions were based on the goal of 90% reduced material and energy use in this particular super-system (consisting of all sub-systems of beverages on the Norwegian market). Future scenario building and “off-site” two-day work sessions were characterised as the pillars in the pilot study and of high value for the participants. The pilot study was co-ordinated and managed by Ole Jørgen Hanssen, Associate Professor at NTNU and research manager at Östfold Research Centre (STØ).

10.1.3 Aims, objectives and the research questions (Chapter 5)

Research questions

The research questions are based on the assertions described in Chapters 2, 3 and 4, which are based on the theory that reveals how ecological and human problems are closely related. Ecological problems cannot be discussed exclusively but must include human activity and needs. Technological needs satisfiers are a major cause of today’s ecological challenges. The main focus of this thesis is to explore the connection between the starting point of a development process and the possibilities of reaching a system design based on sustainable principles. The first research question is therefore:

Q1 How can product and system concepts be designed to promote a factor 10 development?

Factor 10 development should move overall global change in the direction of 50% less consumption and minimum toxic emissions through a focus on equity in human individual consumption and economic activity. The factor 10 pilot study started with an analysis of the beverage systems per se rather than the human needs in this perspective. The process was dominated by this starting point throughout the study and new strategies were locked in the existing systems. The first sub-research question therefore addresses a new starting point for system change:

> **Q1a** Can connected functions and experiences serving the end user be the starting point of co-operation between the main stakeholders, rather than the products themselves?

The next challenge of the factor 10 pilot study was to bring the future view to the operational level in today's decision making and designing. This is a general challenge in the design methodology for sustainable innovation.

> **Q1b** How can a new methodology include a *long-term perspective* and short-term steps coordinated in the development of new concepts, and in the setting of a company and/or organization?

The estimations for the future present a clear picture of the urgent need to change the material and energy consumption on local community levels to meet the global need. This means that the changes have to be based on sustainable principles, as opposed to the development and changes that have been dominating industrialization from its inception to our present time. In the initiating phases of a design process for a new system design, it might be difficult to evaluate the direction of the change. So far, environmental profiles have been presented through quantitative analyses. This is not seen as suitable for ideas which are on a qualitative principle level and still relatively vague. The next research questions address this challenge.

Q2 How can design concepts be evaluated in the early phases of the design process when it comes to their ability to contribute to a future development in a factor 10 direction?

The background material and theory reveal a discussion on what the necessary qualities of future solutions are if we are to promote sustainability. However, what this discussion indicates is that every design project must contain a conscious examination of the long-term goals for sustainability and also examine what the term sustainable means in each particular context.

> **Q2a** How are the different principles of sustainability, guidelines and criteria defined for the new concepts?

The practical transformation of the premises for the new solution calls for a systematic treatment of the principles, guidelines and criteria. When new ideas are generated on the basis of sustainable strategies (principles, guidelines) they need to be discussed and evaluated. The evaluation will guide the selection of the most promising idea for further development.

> **Q2b** How will the principles of sustainability, guidelines and criteria enter the design process to promote and evaluate future factor 10 solutions?

Aims

- To create a methodology for developing holistic sustainable solutions
  - alter the mindset from product to human-activity thinking, integrating human needs in a long-term sustainable perspective
- To develop an integrated tool for designers and the design team to guide and evaluate their concept development in an early phase of the design process towards sustainable solutions

Objectives

- Explore holistic design thinking and ideas of sustainability through eco-philosophy
- Explore the existing factor 10 concept and research
- Capture the pragmatic design approach in practice

10.1.4 Research methodological approach

The background material, theory and pilot study evolved the research questions over a two-year period. The status of the research at this point revealed a need to explore the research questions even more, but now in relation to an existing and completed design project. A relevant case study should contain a system design with a user-centered focus that includes specially developed and designed products and services.

The case study should bring the research closer to the question of the possibility of networks of actors contributing to the development of new solutions in the light of a vision or long-term goals. The case study should also feed the discussion of short-term business activity as a step towards a long-term goal or vision. The Olympic Winter Games in Lillehammer '94 were chosen as a case study (Chapter 6). This choice was made for four reasons:

1) The Olympic Games at Lillehammer had a great focus and final goal experience (human focus).

2) The projects involved are practical examples of how systems, products and services are designed and launched through a co-operation between many different stakeholders to reach a holistic total solution.

3) The project was based on a vision defined early in the project through a tedious process of communication and development of conscious design management.

4) The project has used particular methods and methodology to maintain the expressed vision throughout the project and into the final results (visual profile, systems, products and services).

This case study did not have direct relations to the factor 10 concept. It is the design methodology per se which has features that can be transferred to a new practical approach for radical design methodology based on the factor 10 concept.

Deep interviews gave additional information and shed light on the pilot study and the case study (Chapter 7), especially in terms of human processes which prove to be a crucial part of the practical development. Two deep interviews were also made with respondents from other design fields, referred to as “reality-check” interviews. The interviews were based on scientific and ethical criteria (Chapter 5).

During the entire research process a rather philosophical discussion on sustainability and human-made products and systems was undertaken. This process is seen as a core activity in the total work, although the research approach and results are the most fragile. However, the models (tools) presented the final syntheses, and to a large degree embraced this essential discussion and opened for further dialogue in future design projects.

The application of the research findings is presented as a synthesis of a new framework for radical design projects. The framework includes three models that were tested. The testing, however, was not undertaken in a satisfactory scientific way (due to the lack of time), but did give an indication of the practical usefulness of the new tools developed for design for sustainability, or radical design projects (Chapter 9).

The triangulation and thoroughness in the use of research methods should secure the validity and trustworthiness of the material. The analyses, reflections and synthesis are also presented as open as possible to invite interested parties into the discourse on the material.

10.2 Contributions from the thesis

10.2.1 Theoretical contribution

Radical design depends on business vision and strategies
A human focus is required if we are to find ecologically sustainable product solutions. This theoretical view alters the problem definition of the ecological and human challenges, and comes up against the boundaries within today's business and organization structures. In most cases the designers and development teams are not given the strategic freedom to start from scratch to find new system solutions answering fundamental human needs. The starting point in a project differs from both its prime movers and motivation. The starting point describes the perspective from which the information is gathered and analyses executed. The definition of aims indicates the relevant area of the starting point, and this is in the context of a business structure based on a strategic level.

Similarly, the process of system design, which involves different stakeholders who deliver products and service functions, requires a business structure which places the design function in the company on a strategic level. Finally, sustainable principles transferred to product and system solutions are related to the strategic business level as well, and should be discussed as part of a business vision and strategy.

As an example in terms of sustainability, Hueseman (2003) found two sustainable principles which represented a consensus in the field:

- To close the material cycles and avoid waste
- To use renewable materials and energy at a balanced speed with nature's reproduction ability

As underlined also by Braungart and McDonough, "doing less bad is not doing good". The future solutions to ecological problems will address system change, *not only the reduction* in use of toxic substances, material and energy.

The theory in Chapter 2 shows that sustainable principles, which include the human needs, have at least three aspects. It is important to mention that these principles do not exclude the two mentioned above. The last of the following principles is related to the second of the two mentioned above. The three principles concern

- How to embrace the human experience in the encounter with a product, by this we mean that it leads to spiritual activity such as reflection, creative activity or conscious development with consequences for choice of lifestyle and priority of values
- How to include the cultural and social perspective, and then to promote product life cycles that are sustainable with respect to ethical issues, local adaptation, contribution to the majority and human possibilities of empowerment, such as personal influence on daily work (e.g. in the production of products, repair, recycling systems, and so on)
- How to connect with nature and find material and energy sources, and "product" and material cycles from biological (natural) sources and which are transferable to human mass-produced products

Design for sustainability is to design synergic satisfiers. Synergic satisfiers are a solution which satisfies more than one fundamental need (Max-Neef 1992) without prohibiting the satisfaction of other needs. Similarly, not all needs can be satisfied by a man-made commercialized solution. We must understand the limits of our designs.

Short-term and long-term design tasks

The long-term perspective is introduced in sustainable development so we can perceive the consequences of the planned development to a higher degree than we do today and thereby create some guidelines for the current short-term steps. However, long-term design strategies are part of the business strategy in a company and therefore this type of design discussion should involve the company's senior management. The long and short-term approach in design also depends on the type of company and type of market and products that are in focus. In the design methodology based on the factor 10 concept, long term is defined as about 50 years, whereas short-term steps are within about 5 years.

The factor 10 pilot study operated with a 30-year long-term perspective. These time perspectives are also valid for this thesis discussion. The time perspectives here are defined in connection with the ecological symptoms and estimations of high interest for decisions made today. In a business context, however, one year or even a half year is defined as long term. This depends on the economic activity, changes in the market and vulnerability.

The sustainable guidelines and criteria entering the design process

Sustainable guidelines suggest promising directions within each of the principle areas discussed above concerning the specific issue addressed in the design task. Furthermore, sustainable criteria pinpoint the product and system specification according to the chosen directions (guidelines) and specific tasks to solve in the detailing of a total solution.

The sustainable guidelines and criteria are directed by the choices of sustainable principles and business vision, or are limited by the lack of such.

From this perspective the sustainable principles will enter before the design process is initiated. The guidelines link the principles to the more specific task of development, where they influence what solution strategies are acceptable in terms of a vision including human and ecological sustainability. The criteria will enter in the product specification and the product-detailing phase.

Human processes

Defining the relevant sustainable principles, guidelines and criteria for a new concept also depends on having time for reflection and discussion in the decision-making processes from the business to the product level. Personal development and characteristics of the participants will influence the decisions but so will the method and tools for discussion (Chapter 2).

The deep interviews revealed a connection between the human processes, development of the framework (network, financial support, human resources etc), use of methods and the progress in the project. As one respondent (A2) expressed it: A methodology is not able to carry the process and promote progress in the right direction on its own.

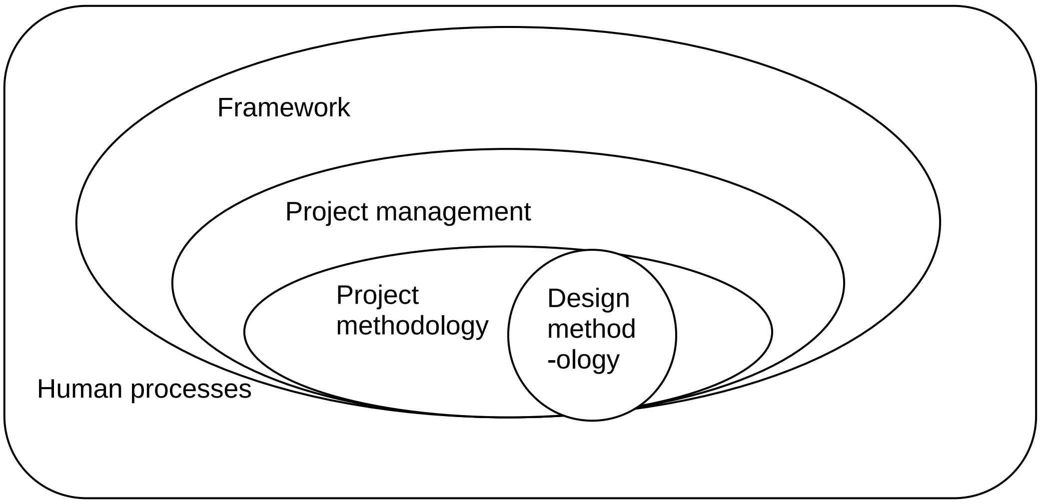


Figure 58 The human processes are important in every aspect og the project. A methodology itself will not be able to carry the process in the right direction. (From Chapter 8.6.2)

A conscious choice of communication (internal in the project team, and external to create support), work methods and distribution of tasks to perform in a design team can affect the human processes causing motivation, involvement, contribution, ownership and commitment (*Figure 65*).

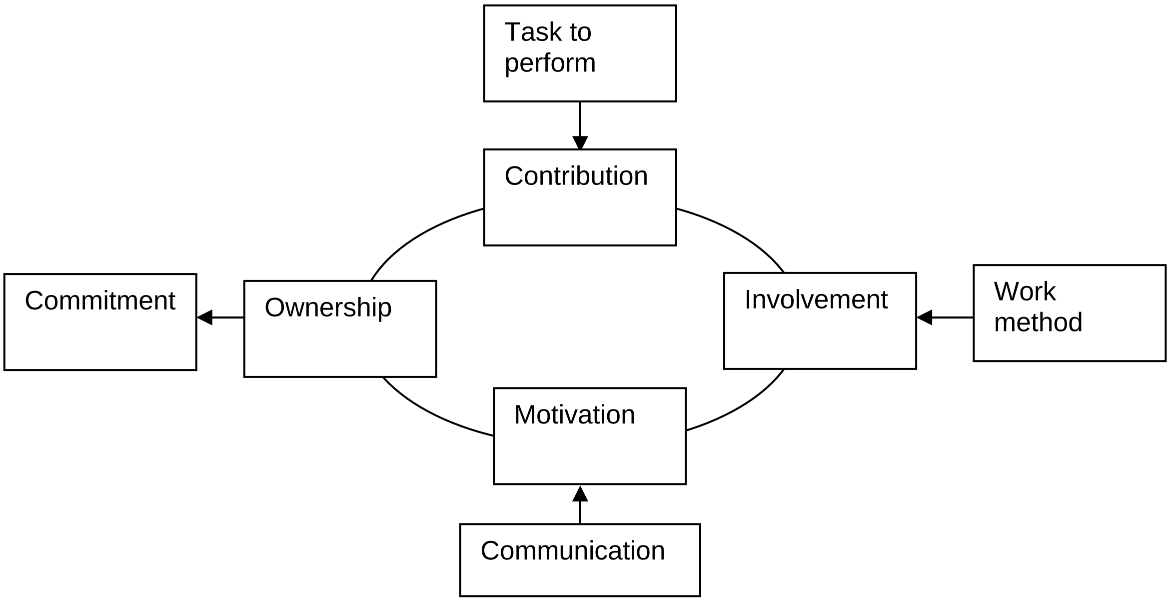


Figure 65 The figure shows a continuous connection between the four elements motivation, ownership, involvement and contribution (from Chapter 9.3.3).

In the process of development and design of sustainable complex systems and products there is a need for common visual tools where the different stakeholders find their role and agree on the vision and strategies that move them towards sustainable solutions. Previous factor 10 projects have a strong technological focus (Weaver et al. 2000). However, the importance of human behaviour is the basis for this new approach. The focus of the new solutions is on the end user, and as the starting point, the aim is to influence and interact with users as customers and citizens. The system perspective is seen as both the means to create total solutions for user needs, and the way to promote radical changes in the direction of sustainable development. However, human focus is not enough to support and create environmentally balanced solutions. The term sustainability must be developed through dialogues and discussions which give the involved parties a common basic understanding from which they can start their work.

10.2.2 Design methodological contribution

The synthesis of the material in Chapter 9 has resulted in a model which is meant to contribute to the initial phases of a radical design project. The initial phases involve the development of the premises for the new product and system development and the transformation of these strategic decisions to a design brief, idea generation and evaluation of the premature design concepts.

The target group for utilisation of the new framework are transdisciplinary design teams and favourable collaboration between municipal stakeholders, NGOs, businesses with an open-minded approach and possibly research institutes (Chapter 9.1.1).

As answers to the aims of the thesis, the methodological contribution consists of a framework for the initial phases of radical design projects. Furthermore, the thinking model, thinking map and evaluation matrix are presented as tools which can be used in the different steps of the development process.

The tools integrated in the methodology should contribute to mapping the relevant qualitative sustainable principles, guidelines and criteria, and should also

- Form a platform for a common vision for the collaborating participants
- Inspire the conceptual design phase in the development process
- Function as a framework for evaluating the early concepts
- Represent complementary knowledge related to figures and graphs (quantitative analyses)

Since the qualitative characteristics of the solution play the main role in the conceptual phase (work with new ideas) in this framework, the new concepts have to undergo qualitative evaluation in an early phase of the design process with respect to their ability to contribute to a future development towards a factor 10 direction. The evaluation matrix is suggested as a tool to contribute to this phase of the process.

The thinking model

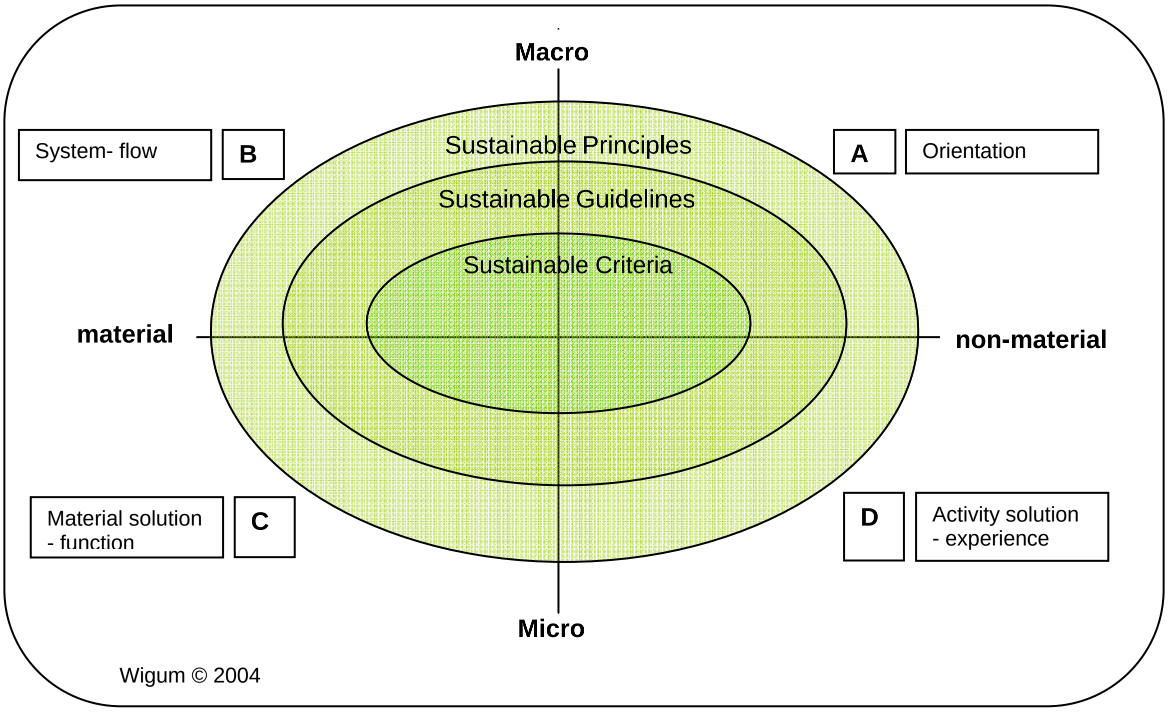
The thinking model represents the material and non-material issues within design, reaching the macro and micro levels. It represents four main areas containing sustainable principles, guidelines and criteria. These areas can be thought about, discussed and analysed, and integrated into new system and product development. The thinking model consists of areas (see more detailed description in Chapter 9.2). Area

- **A** Philosophical thinking, intentions and non-material content in the human-created environment; society (non-material issues on a macro level), area

- **B** System thinking for physical connections, movements and flows (material issues on a macro-level), area

- **C** The material solution, production and physical system structure (material issues on a micro-level), and area

- **D** Human activity, contribution and interaction with the product and system (non-material issues on a micro level).



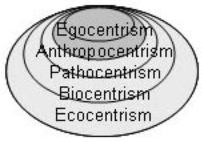
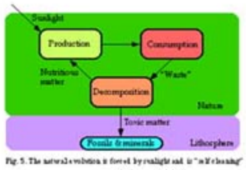
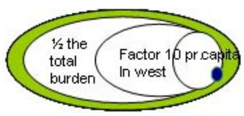
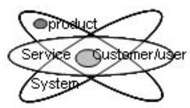
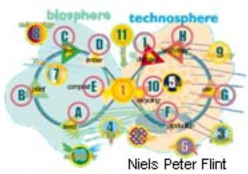
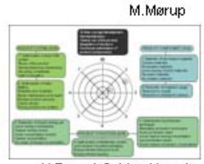
Model 5 The thinking model shows what areas of material and non-material considerations to address, discuss and evaluate in a concept development.

The thinking model may function as a “systematizer” in terms of presenting the information and decisions analysed and “produced” in the different areas, A, B, C and D. Furthermore, idea generation and mapping of existing concepts may also be presented and communicated in this format.

The thinking map

The thinking map reveals the issues within the four areas of the thinking model. However, this map, should be redeveloped and “filled in” by the transdisciplinary design team during the first phases of the design process. The discussion and dialogue comprise the basic tool for creating knowledge (Molander 1996), and the thinking map indicates places for the dialogue to address..

The table of the methodological framework (**Error! Reference source not found.**) indicates where this method can be most useful according to milestones for the different steps in the framework. Important processes are the creation of the product and system vision as well as the strategy decisions for the new development (steps D and E).

	A Orientation (macro)	**B System flow** (macro)	**C Material solution** (micro)	**D Activity and experience solution** (micro)
Sustainable principles	 World view and intention	 www.exergy.se , Göran Wall Material/energy sources	Choice of functions for specific users and their context	Quality life, Meaning 
Sustainable guidelines	Spiritual, cultural and social preferencens Ethics and human involvement and empowerment	 Local and global connection	Principle qualitative solution :”Invited” user activity to satisfy needs 	Needs and desires **The nine fundamental human needs** (Max-Neef 1992) **Material:** Subsistence, Protection **Non-material:** Affection Understanding Participation, Leisure Creation, Identity, Freedom
Sustainable criteria	Rituals (e.g. birth, death, transformation,) Rythm (body, seasons, daily life) Artistic expression	 Niels Peter Flint Industrial ecology	q-product qualities M.Mørup  H.Brezet,C. Van Hemel	Q-qualities experienced by user M.Mørup

Model 6 The thinking map shows the content of the four areas in the thinking model.

The sustainable principles which are represented in the first row of the thinking map are, as mentioned, issues of strategic concern, namely: what is the worldview of the company (ethical, social and ecological awareness), what is the strategy in terms of material delivery and resource exploitation; are the materials renewable? Furthermore, what types of function do their solutions provide; for whom and for what purpose?

The next level of guidelines goes further into the different issues, for example, should the factor 10 concept be discussed in connection to the market and user situation the new solution is opening for? What are the fundamental needs for the final user, and what are appropriate satisfiers for these needs (e.g. use of high-technology elements)? Furthermore, the user’s social preferences and spiritual and cultural practice are explored on this level.

Finally, the criteria are also used in the completion of the solution, and influence how different actors, such as the producers, may co-operate (e.g. industrial ecology as chains of industrial activities), and are also used in the detailing of the product and system solution. Discussion on how the product will affect daily life and promote interesting and fruitful experiences is a part of the one-to-one encounter between the product and the user.

It must be underlined that these are examples of issues that are introduced in the different areas (horizontal) and on the different levels (vertical). This map is a tool for transdisciplinary projects and the issues should be discussed by people with different backgrounds and competencies.

The evaluation matrix

The evaluation matrix (*Model 7*), Chapter 9.3 introduces relevant questions in all the areas in the thinking map. An evaluation of new concepts will include discussions on the decisions on vision, strategies and further specification which are based on previous steps in the initial phases, where knowledge and analyses, priorities and exclusions have been made in terms of each area and level in the thinking map.

The framework for radical design

The methodological framework can be presented schematically in the table below (*Table 25*). Chapter 9 provide a deeper description of each step in the initial phases. The total approach is not suitable for a detail and redesign level, where other methods are suitable, some of which are presented in Chapter 3.5.

The target groups for this framework are:

- Companies/organizations of an innovative and responsible nature
- Developers of new business concepts where there is cooperation between several actors
- Companies/organizations in change and renewing processes
- Researchers in cooperation with companies and organizations
- Initiatives from the local authorities co-operating with businesses and others on the design of systems and services of common goods

The initial steps in the methodological framework are supported to a high degree by the thinking model, the thinking map and the evaluation map.

These tools were tested in a workshop with participants from the natural sciences, social sciences, and humanities, as well as from the design and product development (engineers) professions. Overall, 14 people attended the entire workshop and answered a questionnaire, sent to the participants by e-mail a few days after the event. All participants answered and returned the survey.

As general feed back, the participants (surveys in Appendix XI (in Norwegian)) were asked to point out the strength and weaknesses they saw in the tools. There was high agreement on assessing the models as good tools for discussion (11/14) and communication (7/14). Furthermore, eight of the 14 participants experienced the tools as “door openers” for various viewpoints and disciplines and six participants understood the models as inclusive for a variety of values. It was especially commented that the thinking model defined visual spaces for the non-material aspects as much as for the material. This was seen as very positive.Half of the participants found the thinking model and map complicated to comprehend, however the thinking model was appreciated by many of the participants. Similarly, half of the group found the content of the tools unclear and more than half (8/14) saw it as a drawback that the process of using the tools needed to be facilitated to be understood and supportive in practice.

The thinking map most likely needs to be further cultivated in the squares and layers. By developing the map more clearly, the need for facilitation might decrease and the tool might become more efficient.

This workshop does not represent the authentic working context, neither for the tools nor for what the framework is meant to be. Nonetheless, it was interesting to see that eight of 14 participants found the model *very useful* for directing the focus of their vision (step D), as defined in the workshop, and six found the same aspect as *somewhat useful.* No participant found this step useless. This was one of the most important steps in the new framework for radical design projects.

Radical design framework milestone	**Focus**	**Tools/methods**	**Cross-references to models, figures, tables and illustrations**
Project planning, and initiation of project	Time schedule, combination of participants		*Figure 64*
A *Intro/definition of aims*	User analyses of new product and system - Human needs and activity	Human focus map Thinking model and map (Guiding graphs quantitative evaluation)	*Model 6* *Model 5* *Figure 67* (*Table 28*)
B *Mapping and analysing*	Stakeholders and their contribution to the system Environmental challenges	System map Thinking model and map Life cycle – mapping Functions related to ecological impact and possible solutions	*Figure 68* *Model 6* *Model 5*
C *Future scenario building – possible futures*	Society, longterm perspective	Scenario techniques	Figure 47 *Table 16* *Illustration 29*
D *Creating a vision – desired future*	System and product vision - qualitative sustainable principles	The thinking map Communication through the thinking model Visualization	*Model 6* *Model 5* *Illustration 30* *Figure 69*
E *Strategies*	Long term and short term - qualitative sustainable guidelines	Short–term concepts towards long-term goals	*Model 6* *Model 5* *Figure 71* *Figure 70* *Table 26* Table 27
F *Design brief*	Specific area for new solution, problem or desire - qualitative sustainable guidelines and criteria	The thinking map	*Model 6* *Model 5* Figure 72 Illustration 31
G *The concept design process: Designing in light of future scenarios*	Human activity, satisfiers in the local context	DOS, Use-case analysis Human characters and prime movers in the different futures Parallel design,	*Table 22* *Illustration 29* *Illustration 30* *Illustration 16* Figure 28 Figure 30
H *Early concept evaluation, qualitative evaluation* *Selection of the most appropriate/ promising design concept of new product and system solution*	Qualitative principles and guidelines	Evaluation and guiding questions Questioning the conceptual ideas based on the vision and strategic decisions	*Model 7* *Table 28*
Follow-up Product, (service),	Eco-design methodology used within the new radical		

system design	design framework!		

Table 25 Structure of the methodological framework, initial phases from A to H.

10.3 Reflection on the strengths and weaknesses of the research

10.3.1 Strengths

This thesis initiated the research within a rather holistic design approach where the aim has been to reveal the connection and relationship between different approaches and perspectives within design for sustainability. It has suggested a communication process that employs *the thinking model and thinking map* in transdisciplinary teams to pinpoint the various dimensions in a design process, and where a new solution is used so that this process develops in a balanced way.

The combination between quantitative and qualitative information used in this thesis is a focus which may be useful because it includes different personalities and may improve the chances that further steps will find holistic solutions to common problems. One of the strengths of this research is that it concludes with at least three tools and a design approach which can be tested by others. This makes it possible to evaluate the material in the thesis.

The flexible research design is a research approach which opens for human reaction and action and prevents the researcher from being static in relation to the research material; rather it is hermeneutic in its approach. This is also seen as the characteristic of creating knowledge in phenomenology, which is the science theory employed in this thesis. The work has a progressive nature; which is a result of the interrelation between the research themes, the involved colleagues, the interview respondents and the researcher: the PhD candidate.

10.3.2 Shortcomings

The wide research approach is not conducive to going deeply enough into the different areas of data collection, analysis and documentation. Generally, the analyses of the material show a need for transdisciplinary work in designing for sustainability. The research, which is undertaken from the professional approach of industrial design, has to introduce several issues rather superficially. Nevertheless, professionals within different fields covered by this study will find room for more extensive discussions.

Additionally, since the aim of this research was to find the connection between various necessary elements in design for sustainability, the appropriate research methodology had to be explored as well. The relevant content of the empirical material has not been extracted to its full potential and brought to the final discussions. Lack of appropriate methods and also perhaps too wide a research focus are some of the reasons for this.

10.4 Further research

10.4.1 Additional testing of the methodological framework and tools

The methodological contribution in this thesis should be scientifically tested in authentic development and in research projects consisting of a transdisciplinary teams and collaborating stakeholders. Politicians and municipal officials should also be more deeply involved in this type of testing. The tools previously described also require that these types of participant are involved in design for sustainability.

There is a general need to create more practical examples, and to go deeper into the different points of view to see the ideas and the theory, the methodological approaches for radical design and factor 10 development come to fruition.

10.4.2 Specific challenges within the methodological framework

Quantitative analyses supporting the design process (from Chapter 9.4.1)

It may be questioned whether the LCA data collection in the pilot study could have been even more useful, also for the more conceptual design phase, if these analyses had been executed at a later stage. The motivation for the LCA data collection could then have been grounded in the need for information about the chosen system with respect to users and their activities, markets, and specific delivery from the various companies. Recommendation for further research: a Life Cycle Assessment should not “live a separate life” based on a standardized methodology if it is used to support the design process. The present format of the final results is too rigid and not useful in specific design tasks. A more flexible LCA should be challenged in new research.

Long term and system design for short-term steps

It is hard to imagine future scenarios only considering one product and not its context. Long-term thinking opens for a system view and changes in a larger system usually, but not necessarily, call for a longer time span. The future scenarios made in the pilot study (see Chapter 5.2.4) do not necessarily have to be “future” related. However, the freedom of thinking within a wider perspective was highly appreciated by the business participants. To think “in the future” detaches the thoughts from today’s solutions, which is a useful thinking-out-of-the-box exercise. Nevertheless, deeper research testing has to be undertaken on the process of going from future scenarios and system thinking to the short-term steps in the present (Step C, D, E, F).

Different companies and stakeholders with a common vision

The vision for Lillehammer ’94 was created by management; the themes for the design process were made by the head of design. For whatever elusive reason, the vision and the themes harmonized and therefore became good and inspiring sources for the visual design profile. When many stakeholders are collaborating, a conflict may arise between the individual company visions and strategies and the common vision, which should be the guiding light for the larger collaboration (see Chapter 8.8.1). Step D, c*reating a vision* in the framework, is a very important step that should be explored further.

10.4.3 Further specification of the factor X concept

The global perspective in the theoretical background material of the factor 10 concept must be transferred to the

- local and practical situations (the value of the “factor”)
- discussions of specific use of materials and energy sources

Furthermore, there is a challenge in the factor 10 formulation per se, for example

- how is the technological unit defined in the equation of the factor 10 concept (see the equation Chapter 1)
- the prosperity which is an economic unit in the equation is rooted in existing economic models. Striving for radical design and factor 10 development within the present economic system is a major challenge

10.4.4 Challenges in creating appropriate scientific approaches

Scientific measurable knowledge can in this situation contribute to better decisions on the choice of materials and production processes, but it is hard to see how the scientific methods used today are useful for considerations on human quality in a long-term perspective.

Fundamental experiences and fundamental understanding of how the world is created that will help us to be ecologically sustainable might be a natural part of our basic instincts to survive (Næss 1989). Developing qualitative research methodologies which explore and integrate such subtle and essential non-material issues within any number of relevant fields of knowledge is another major challenge.

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www.hancockshakervillage.org/old/shakers.html)

www.detnaturligasteget.se/DnsSwe/Start/ (**Table 8**)

www.norskform.no

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www.tine.no

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Appendix

All references related to sections in Appendix are found in the main reference list in the thesis.

I. Reference projects

Design for sustainability projects	**Focus and theme**	**Goal or scope**
-STD, 1998, Jansen, Vergragt, Weaver et.al	Factor 20, Sustainable Technology Development	Experimenting with backcasting methodology, in the area of water, food, transportation, chemicals and housing
-sushouse/DOS, Vergragt, Manzini….	Sustainable Household, food, clothing and……	Development of methodology, Design Oriented Scenariobuilding through international cooperation
-demi, Dewberry et.al	Design for Sustainablitiy guiding internet source	Creating an interactive tool both for educational and professional purposes giving examples and guidelines for development processes
-HiCS, 2001-2003, Manzini et. al	Highly Customerised Solutions Delivery of food to people with reduced mobility	Development of new PSS methodology which is tested in businesses
-Telecenter service system, Morelli et.al	Product service system, use-case studies	Including methods from other disciplines in settings and framework for designing product service systems
-SOLD project in Cranfield Univ.	Product service systems	
Eternally yours	Human relationship to products	The project should explore the qualities of products and systems which create protective emotional feelings for products
Suspronet, EU initiative	Product service systems	This is a international network of researchers and designers who focus on both academic research and good practice
-other thesis: Sherwin, 2001 Van Hemel, 1998 Annegerd Liseth, 1998	Electrolux, Early phase conceptual design Survey on experienced pilot-studies in Dutch SME Compac, Economic evaluation on sustainability concepts	

Table I Reference projects with different relevance to this thesis.

II. Evolvement of research questions

January 2000

The assumptions and research questions were presented with three themes:

A1 Assumption: The service can introduce a new dimension opening for “human-experience”- related values.
To incorporate the intended values into a product concept, the material product can be supported by services and non-material (digital) systems. This also means increasing the company activity connected to the product, but in a non-material way, not through increased quantitative material units produced.

Q1 Research question
Can product systems involving services and non-material digital systems create this type of holistic experiences (Figure 1)? How can non-material values be experienced through service product systems? How does it influence the material product?

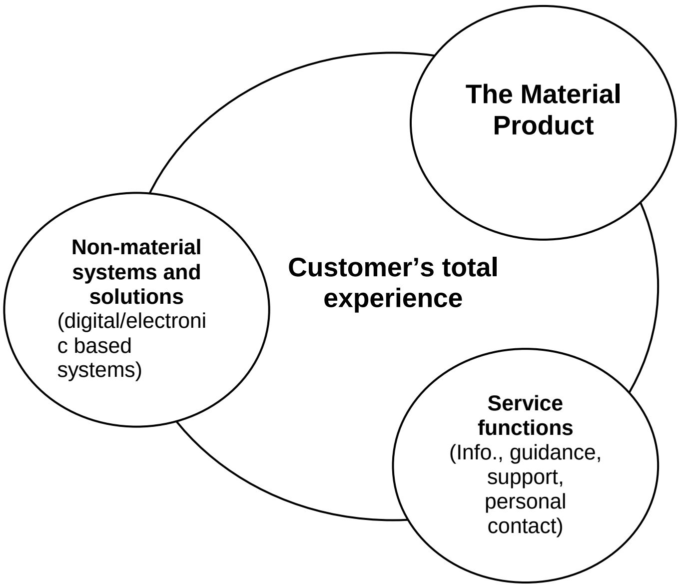


Figure 1 The companies may increase their activity in non-material systems and services, and in quality of material product, instead of quantity of material production units (Wigum 2000).

A2 Assumptions: Designing for life quality is requiring untraditional expertise integrated in the design teams
Going back to the keywords “life quality”. The human senses are the receptors for the human being to achieve experiences giving input to the emotional, spiritual and intellectual life (Soesman). Through our body with its rhythm, cycles and movement we are part of nature and its ecology. If the design team focus through this perspective on human behaviour actions and desires, it might lead to a change in the choices of the Eco –design strategies.
If a product, its functions and appearance can contribute to these aspects of human life, it might lead to a change in human attitude and lifestyle. This is, however, hardly developed by a single designer and a company with a traditional engineer, economist and marketing manager. We might need to involve totally new professions into the product developing project groups, like philosophers, social anthropologists, medical experts, artists and others specially and indirectly related professions to the function of the product, the service and the total systems being developed (Papanek 1995).

Q2 Research questions

How do designers and companies work to create these concepts? Is there a need for developing working tools which will make it possible?

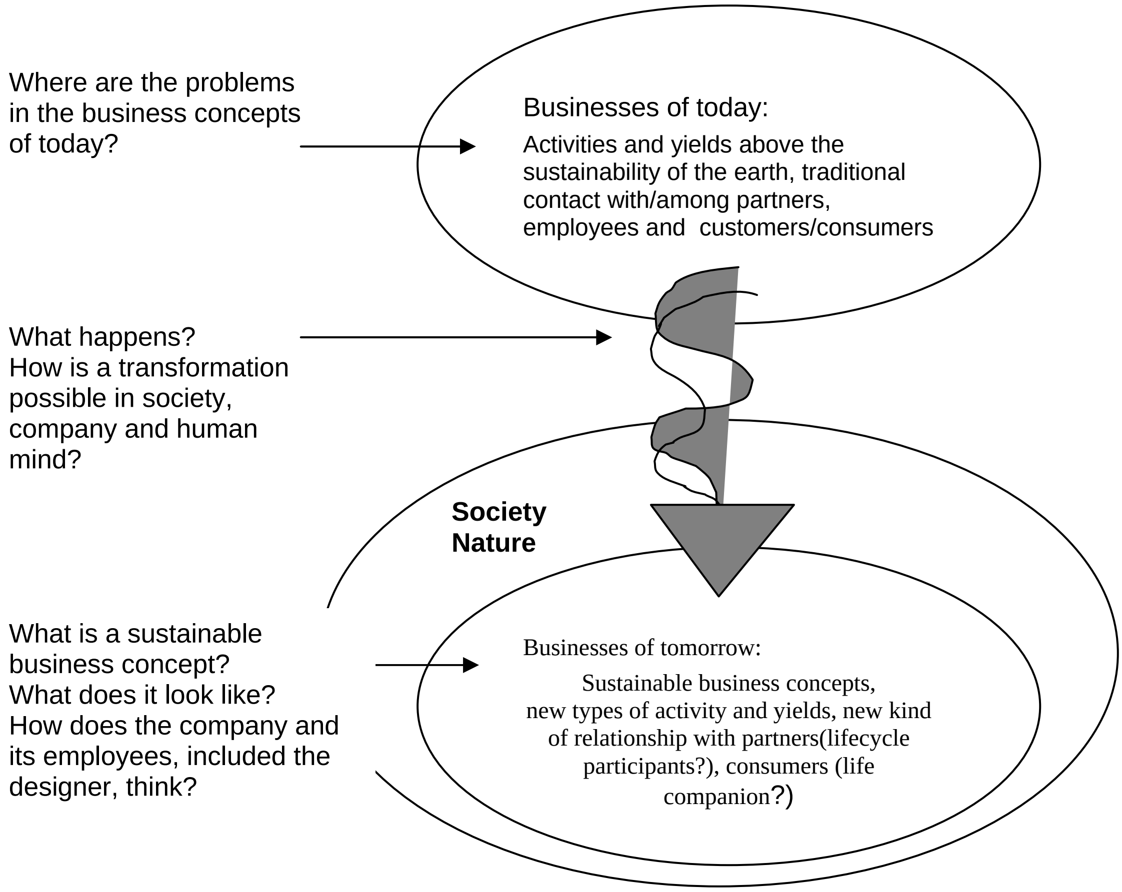


Figure 2 Businesses of today might need to change in order to meet requirements for tomorrow (Wigum 2000).

A3 Assumptions:The consumer's need in focus of development requires company networking and open communication

The task might be, to execute experiments and research in order to develop working methods and methodology concerning transdisciplinarity. The perhaps most interesting part is the co-operation between different companies on an equal basis, in the sense of defining each other as equal partners meeting the consumer's need for a satisfying experience. This might contribute to openness in mind and knowledge, which seem necessary for change; to be able to develop total product concepts for the future (Figure 2). Companies, employees, *and researchers* must become able to communicate across own discipline and above their own company products to see the possibilities in other specialities, creating optimal solutions for the consumer, the company, the society and nature (Figure 3).

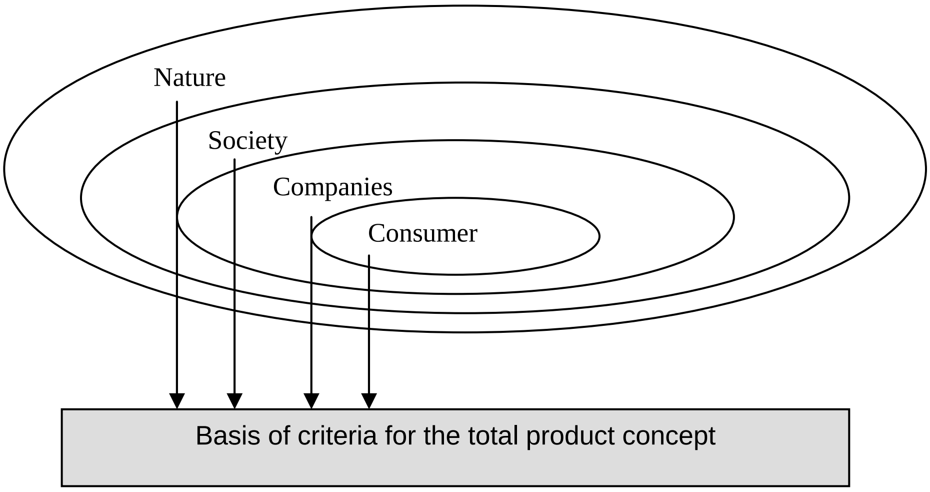


Figure 3 is illustrating the connection between "the four masters" creating the basis and constraints for the criteria in development and design of a total product concept (Wigum 2000).

Different services can also be connected to the life phases of raw material extraction, production and waste treatment (and already are). Making connections between companies (and consumers), the flow of materials and energy can be controlled and used optimally also through service support systems. Industrial ecology is through this definition, the creation of flow between the biosphere and technosphere, involving the materials and energy into as many controlled and closed cycles as possible.

Making raw material extraction, production and waste treatment as locally connected as possible, the closing of loops might be done more easily. Reaching the market through service and digital communication and function systems the company will be able to follow up the products and the consumers in an individual way, despite of the location of the consumer.

Q3 Research question
Can the product service systems decrease the total globally material and energy consumption?

Most of these questions were too wide and without indication of how a research methodology could be applied to find data and material to illuminate and penetrate the issues. However, these initial questions gave a direction for further evolvement.

February 2001

Assumptions	**Research questions**	**Areas of concern**	
A.To change the direction of the development of today's western lifestyle, which leads to serious ecological disturbance, high innovation in thought and practice within production and consumption is critically needed.	Is the terminology "Factor 10" or "Factor x" suitable for communicating the global and complex picture to companies?	• The abstract view of Factor X • Factor X strategy vs. design methodology • Visual communication methods	

B. By changing the focus to concern needs and functions, radical new ideas are easier achieved and the design of new solutions might become immaterial (service) as well as material (product)	What can be defined as a service and how wide should the definition product-service-system reach?	• Strategic innovation • Product extension • Service extension • Product innovation	
C. Technology does not in it self solve the ecological problems. Non-material consciously chosen values must become more visible in the design process for the new product concepts to become ecologically sustainable.	What is the critical characteristics of a product-service-system for it to be ecologically sustainable?	Values concerning • Human (customer and employee) needs and ethics • Natural resources and cycles • Society needs (local and global)	Consequences on: • Human • Nature • Society
	How will the design of product-service-systems differ from the traditional eco-design methods?	• Conceptual design methods • Team work • Company co-operation	
	How can a product-service-system be measured concerning its environmental impact?	• LCA in wider extension • Economic evaluation	
D. Most companies must go through a change to create a culture which gives room for strategic innovation based on both hard and soft core values leading to business strategies for ecological sustainable end products.	What are the driving forces towards a strategic and culture change in direction of ecological and human sustainability?	• General and task environment	
	What role and tools may the industrial designer have in implementing the strategic chosen values of the company into the results of the design process?	• Participative management • Strategic innovation • Product innovation • Self-mangement teams	

Table 2 In the beginning of 2001 the versions of research questions were focusing more explicit on the Factor 10 concept, still, the product-service-systems were in focus.

III. Business organization development and change

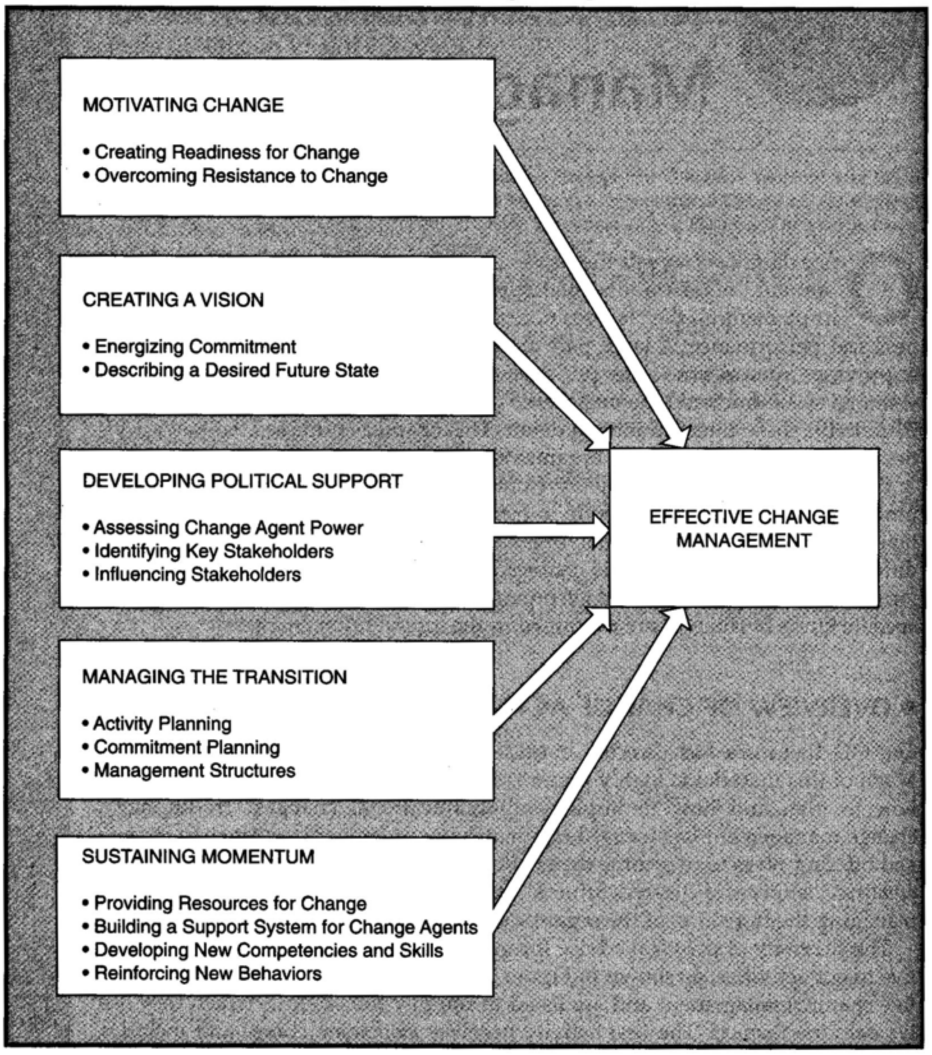


Figure 4 Issues for effective change management (Cummings and Worley 1997)

Design management: Design as a strategic tool in business

When design enters the arena of economy, business and strategies; the product is evaluated in a new perspective. Suddenly the total volume and the production efficiency, sales channels and marketing profile are of major importance. Companies always inhabit a number of “silent designers”, non-designers who have influence on the total design process however with other main intentions than formal aesthetics and future sustainability. These are especially the marketing professionals (Bruce, Cooper 1997). In order to use design as a strategic tool in a company, the decision makers must inhabit knowledge about the potentials in the design function, and further, how it should be integrated in the company in order to exploit this potential. Firms often evaluate design as a one time investment rather than a long term strategic tool (Bruce, Cooper 1997). This view also affects the placement given to the design function in a company.

Bruce and Cooper (1997) mention six key factors for successful design projects concerning the design management of the projects (Roy, Potter 1993 in Bruce, Cooper 1997):

1. Clear project initiatives
2. Comprehensive design briefs that includes information about the target market

3. Regular communication with design
4. Top-level commitment
5. Sourcing of appropriate design skills
6. Integration of design with other corporate activities

Innovation through eco-design

Eco-innovation is outstanding implementation of radical ideas which will meet future needs.
One differentiator between radical and business-as-usual approaches is the willingness to cannibalize successful produce ranges with new ones (Fussler 1996).

Innovation is operating on different levels to create and implement new concepts. This only creates value if it combines three operational disciplines (Fussler 1996):

- Response to future market needs and openings
- Creation of genuinely new ideas for meeting these needs
- Achievement of outstanding implementation of the ideas

Loosing one of these disciplines will lead to incremental improvements and products the market does not need, or great ideas, which will never reach the market place. Innovation is realized at the analytical, strategic and creative levels.

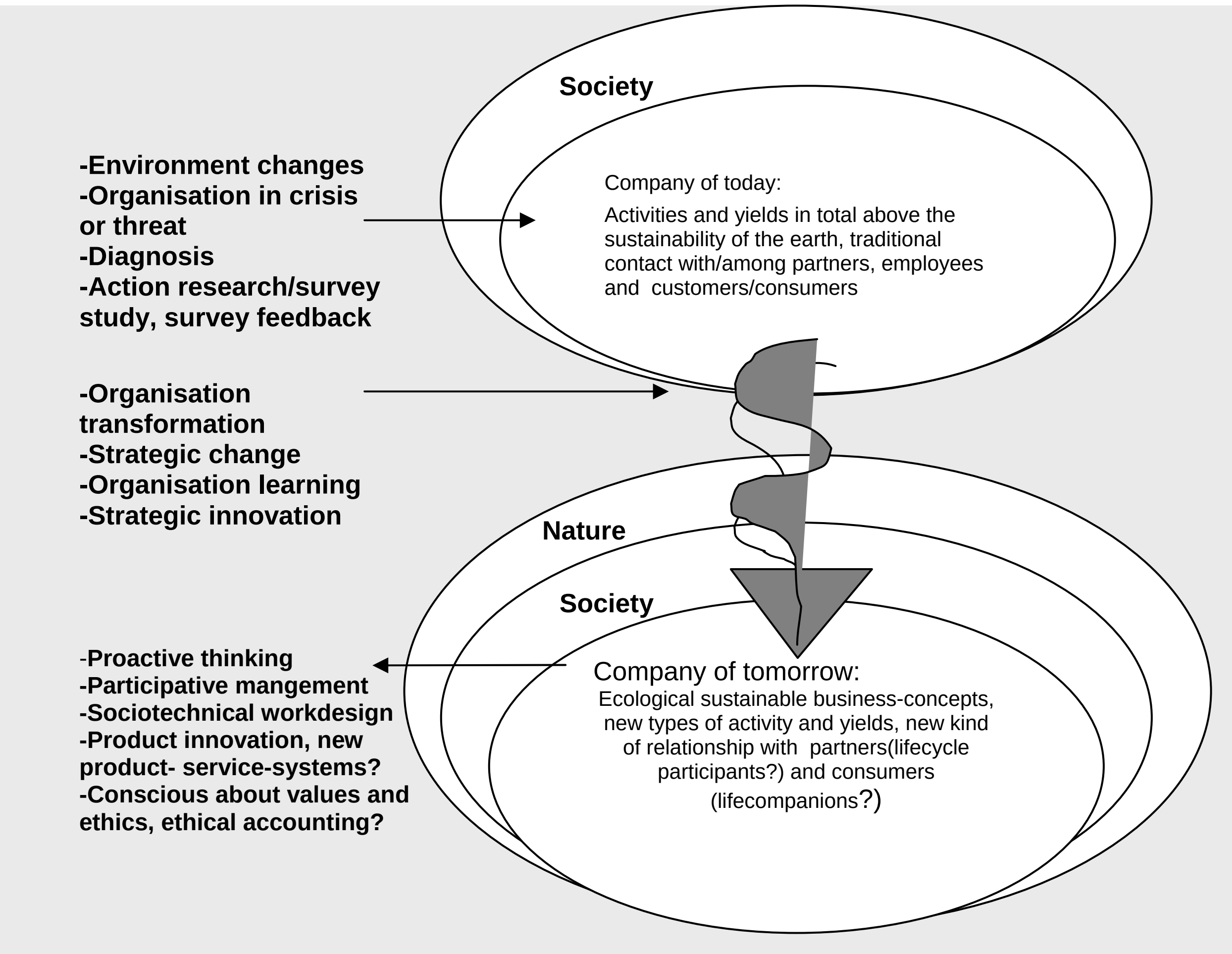


Figure 5 Organisation development and change. There are unlike methods in OD for diagnosing, choosing interventions, and creating change within an organisation. The methods are depending on the mission and intent of change (based on Cummings and Worley 1997, Wigum 2000).

The triple bottom line

Accounting systems have been developed for environmental issues concerning industrial activities and similar is accounting for ethics and social issues being developed. The environmental accounting is based on life cycle assessments and pollution prevention assessments (Figure 6**)**.

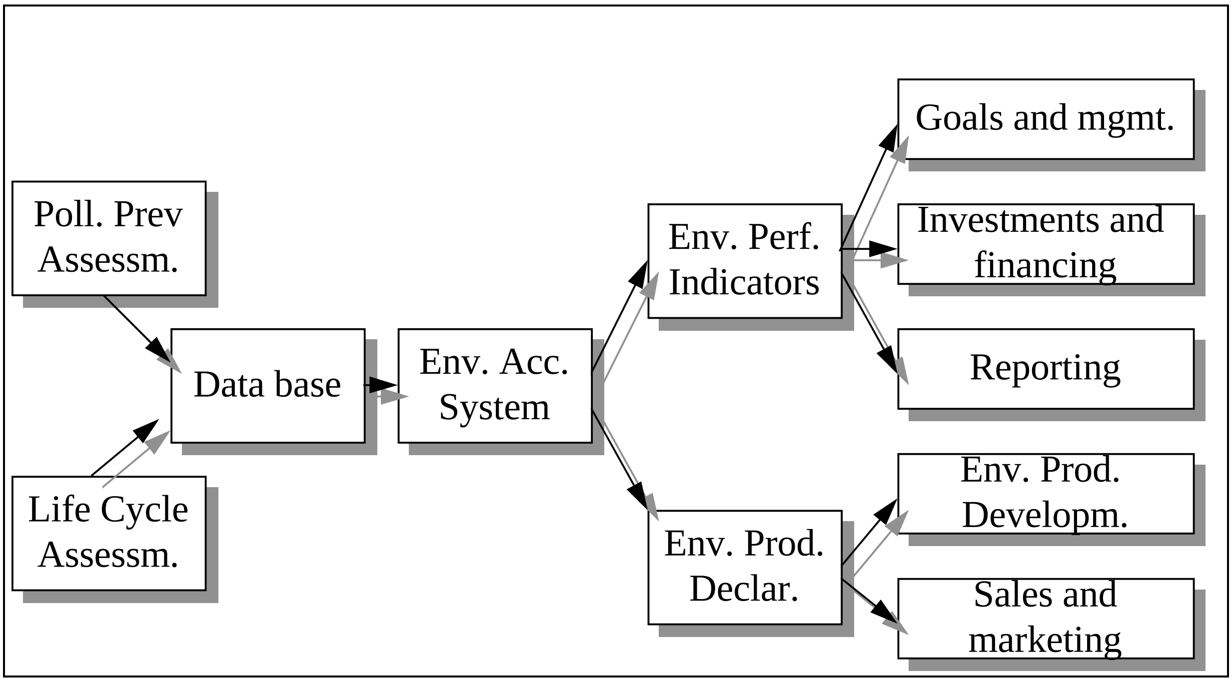


Figure 6 Principle structure of the relationship between different Environmental Management Tools and their applications in decision making and communication (Hanssen 1998).

The companies and society will in this perspective operate with *the triple bottom line*, meaning an integration of ecology, social and economy aspect in the accounting. However, all these issues can be discussed and acted upon in diverse strategies based on different world views, cultures and intentions.

IV. Business profile, vision and innovation strategies

Business strategy and Strategic view

The organisation strategy involves the structure of a company, the culture, routines, business strategy, etc. Which functions, products and services the business should be based upon, must be reflected in the characteristics of the organisation of the company. If the business strategy is transformed, the organisation also might need to be transformed, or less dramatic, the organisation must be developed further to support the new concepts based on existing, values, norms and structure.

Strategic innovation

The article written by Constantinos Markides "Strategic Innovation", is generally describing the steps towards new thinking by redefining own business and business relationships towards their own customers, products and competencies. Markides is Associate Professor of strategic and international management at London Business School.

Markides mentions seven examples of different corporations like Canon and Apple, who have managed to succeed in attacking the established market without the help of radical technological innovation. The common elements for their success are that they "broke the rules" of the game in their industry branch. Canon started to differentiate from Xerox by focusing on the end-user in small and medium companies and personal copiers.

Apple also turned to the individuals and the small businesses in the market. Apple purchased their microprocessors from outside and put their own resources in the interaction design between the user and the computer. IBM on the other hand reached for the large corporations and manufactured the heart of their computers.

Strategic

Innovative Ecodesign is strategic in nature asking searching and challenging questions of both design and companies. This is articulated in the notion of designing 'new business' (extending existing and creating new opportunities).

Sherwin (2001) p. 150 Findings in terms of eco-innovation and introduction of new design through e.g. product service systems.

Motivation

The mental models each single individual is operating with are reflecting ones beliefs about an issue. These mental models need continously to be questioned by asking "why" (Figure 7).

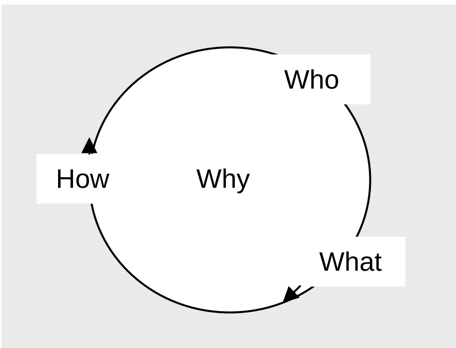


Figure 7 Markides (1997) is explaining the success of Canon, Apple and others by their strategy of asking themselves Who are our customers? This question is leading to the next questions: Who do we want as customers? How are we meeting their needs and why?

This empathic approach (Burns 2002)(Lerdahl 2001) is promoting a human focus. The companies will see the human activity as a starting point for serving a set of functions either through a new (service) system or both new products and systems.

Innovation - "Breaking the rules" to reach the wanted customer

The whole business organisation must be managed properly to give the new strategy a chance. Company strengths and weaknesses have major impact on the new strategy, which is under construction, and these should be combined with the customer needs and wants.
The real innovation is to go beyond the obvious and to truly understand what is behind the customer's assertions and what products or services the company can develop to satisfy the customer needs (Markides 1997).

Identifying gaps in the market that can grow and become massmarket is essential for establishing change. These gaps can be segments other companies have neglected, needs not served well by other companies or new ways of producing, delivering or distributing existing or new products and services.
There are three basic issues on strategic level (see also ch. 6.1.4):

- Who is going to be the customer of the company?
- What products or services should we offer the chosen customer, and how should we offer these products?
- What business does the company believe it is in?

These questions should lead the company to it's customer.

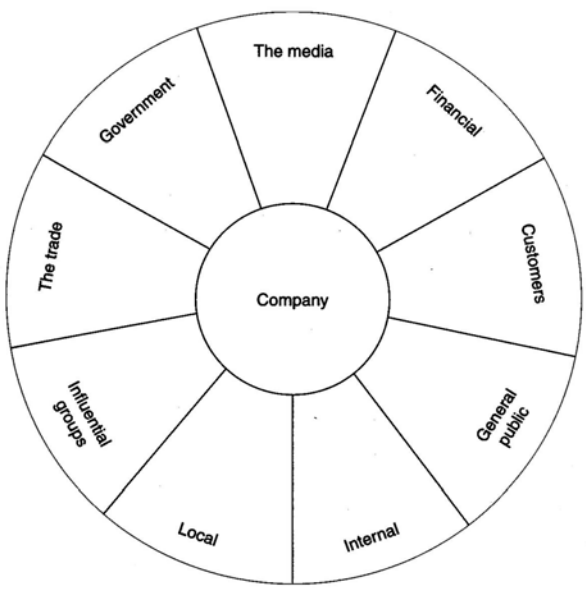
Corporate identity and branding

Bruce and Cooper refer to Michael Beirut and his definition of corporate identity as the sum of the ways that the institution represents itself formally as well as symbolically. This includes its communications, also through products and services, its property and facilities and the attitude and behaviour of its personnel. The corporate identity is, however, just as important in terms of bringing all employees together and make them feel part of the same company. Nine important publics for promotion of the company image is presented by Bernstein(1984) (Model17).

The products and services are thus affected by the corporate values that are defined as a fundament for its identity. The brand as communication channel for a company should give signals to different recipients. A company can also have different brands in its strategy, there will then be a hierarchy in the communication where either the brand or the company name is the dominant carrier of values. The different brands will also represent individual value profiles.

Brand values may be either passive; experiences and impressions given to the market and stakeholders over time, or active by directly being presented in the products and the physical expression as perceived value (Bruce, Cooper 1997).

Figure 1.5 The nine publics of a company image



Source: Bernstein (1984)

Figure 8 The nine publics of a company image. The company must relate its communication to nine different publics according to Bernstein (1984) referred to by Bruce and Cooper (1997).

The meta-product

Carl Erik Linn (1993) has coined the term “meta-product”, which reflects the associations of individuals in a market perceived in connection with a certain product, brand or company name. These associations are represented in economic willingness to pay extra for products carrying this brand or for products that origin from the certain company.
“Added value” may be another more abstract and general attribute of the meta-product. The marketing of a product is a process with possibilities of developing additional values in a product; the meta-values. These values are not necessarily directly related to the physical expression in the product or the service functions, but may be rather a story, which is connected with the product and therefore establishes a status within certain market groups. Linn is also underlining the paradox of price: a high class product is worth its price because of its high price to the end-consumer. It must, however, be distinguished between the final market price and the production and distribution price. The five analytical categories, which are useful in terms of the buyers of a product and their behaviour are:

1. Social identity
2. Business relation
3. Accessibility
4. Desires/wants
5. Utility

According to Linn, the utility of a product is most frequently expressed as the main cause for a purchase, or even the only cause. It is, however, not so. If a purchase is done privately or in a business context, or even in situations where only an advice for a purchase is given, there are almost always other criteria, which are present next to the pure utility. By analysing the utility of a product compared with a buyer’s decision, these other criteria are more clearly exposed. The utility of a fur-coat, a Rolls Royce and a bottle of Dom Pèrignon, is to give warmth, to transport people and to relief thirst. The same utility is also inhabited a sheepskin coat, a Lada and tap water. Nevertheless, the utility functions include also all the other “objective” measurable parameters, and aspects which are often defined as quality.

Carl Erik Linn (1993) concludes that the product development should be seen as a continuous chain of activities towards the moment of purchase. This includes considerations in the development and processes concerning the final price, distribution, the brand image, the communication concept, the design and the function of the final product. These moments are then related to the buyer’s perception in relation to social identity, business relation, accessibility, desires and utility.

The “considerations” are connected with an evaluation according to the company profile, consciousness about their own business activity and their value priorities. The evaluation of the different chain activities can be executed through different methods such as Total Quality Management. The environmental performances of a company including the profile of its products and services are becoming a high priority issue in an increasing amount of companies. Green marketing, environmental labeling and company societal responsibility are all approaches, which are meant to communicate with the consumers and their perception of the products in the moment of purchase.

V. The philosophical sources and methodological argumentation

The three philosophers have been chosen as basic references in this discussion, as a consequence of their explicit interest in life as such, human beings and the relationships and interactions between human beings, between human beings and nature, and between human beings and the material surroundings.

Martin Heidegger (1889-1976) was engaged in the human languages but also interested in the human expression through art and technology. He was influenced by the phenomenology of Edmund Husserl.
Hans Jonas (1903-1993) who was the student of both Heidegger and Husserl in Berlin (1921-1923), is discussing ethics and humanism in his most important contribution *The Principle of Responsibility,* and is later specifically discussing medical research and ethics connected to pedagogy and industry.
Arne Næss (1912-) is the founder of the deep-ecology (1970), but in his early carrier he was philosophically influenced by the positivistic traditions from the Vienna Circle. In deep ecology he is connecting the human experiences with the reflection and the insight concerning the acknowledgement of human as a part of nature (ontological ethics). During the Second World War Næss became highly influenced by the thoughts of Gandhi, and participated in the peace movement from 1940 till 1955.

Short overview of philosophical argumentation

Logics is covering the systematic research of propositions, considering different kinds of incompatibility and contradiction. This research is connected to the study of logic argumentation, justification and proof (demonstration)(Gullvåg 1990).

Argumentation is a systematic way of thinking, which connects causes to conclusions with the purpose of underlining that the conclusions can be verified.
On the other hand, the causes themselves must be verified and consistent in order to bring in front a verified conclusion.

We can distinguish between different kinds of argumentation. Firstly, there is the valid (analytic, deductive) argumentation and secondly, the reasonable argumentation. In an analytic, deductive argumentation, the conclusion is expressing what is within the content of the premises, the causes. If the premises are true, then the conclusion must be true. The argumentation is deductive.
Example: All circles have 360 degree rotation.
In an “expanded” argumentation, the conclusion claims something more than what the premises are including. Thus the premises are valid, they can not guarantee the validity of the conclusion, and however, they can support or present the conclusion as reasonable.
Example: All swans are white.
Both sorts of argumentation can be useful in different perspectives. In order to develop new knowledge the reasonable argumentation seem to expand our knowledge above the existing in a way which the deductive argumentation can not, on the other hand is the deductive argumentation a tool to increase our knowledge of the premises themselves and their interconnection (Gullvåg 1990).
The “expanded” argumentation often leads to conclusions, which include experiences from the actual world which has not been included in the premises for the argumentation.

According to Habermas one can distinguish between tree types of validity claims for propositions in argumentations (discources) as fundaments for decision making:
1. Claim to truth provable via empirical facts, concerning the sum of existing state of affairs.
2. Claim to correctness discussible via pro and contra arguments, concerning situations and interactions within the social world.
3. Claim to truthfulness explainable via subjective decision making, concerning individual experiences and attitudes.

In order to vote for an argument one might give “good reasons” like certified facts or argumentative skills in case 1. (theoretical discourses) and 2. (practical discourses). In case 3. one cannot confirm a statement just through corresponding arguments but has to demonstrate it via consistent behaviour. If one asserts for instance to be vegetarian, eating beefsteak contradict this commitment (Habermas, 1988, 68).

VI. View of epistemology, how to create knowledge

6.4.1 The philosophy of science used as a tool to include practical fields in science

The philosophy of science shows us that there are many differentiate approaches to theoretical scientific knowledge. It also reveals a disagreement between different traditions of what is science, and why it should be defined in certain ways.

The more practical disciplines are not part of any theoretical scientific traditions, and researchers within these fields do therefore need to ask many basic questions when thoughts of scientific research is entering their arena. The basic questions are more easily skipped in the traditional scientific fields, so the evolvement of philosophy of science or perhaps even a paradigm shift, will therefore, in our time, more easily occur within the fields, which are experiencing a need for multidisciplinary work, or within practical fields, which until now have been classified as unscientific, such as arts and crafts.

Different ontology and epistemology is appearing through new demands

In the more practical oriented professions based on a non-academic background, there is seen a switch where research is beginning to appear, and their educational systems are trying to integrate a scientific focus in theory and work. The motivation may be both political and strategically, but challenging questions are arising, concerning what science at some point was meant to be and what the different professions will like it to be in the future. There seems to be a danger when the practical professions are told to become scientific, since traditionally, the scientific methods are not holistic, but have had a goal in revealing guidelines and models, which shall give predictable results, independent from the person using them. Intuition, experience and personal character of the researcher are aspects which have been avoided as influencing factors in the scientific work on the natural and the social side. The methods which are used are therefore not trying to make these factors visible, since they are not supposed to be part of the research.

As scientific research is entering parts of the more artistic or practical professions, this has not been satisfactory, and therefore there has been a strong need to look at the philosophy of science, and find alternative approaches to the objectivistic ones, which are the subjectivistic approaches. Two of these may seem to be the phenomenological and the hermeneutical approach. These two directions are trying to include the subjective side of the research into the interaction with the object, but in some “versions”, a more holistic perspective connected to the object of research as well.

The choice of a smaller picture for scientific research vs. the search for greater understanding within a worldview

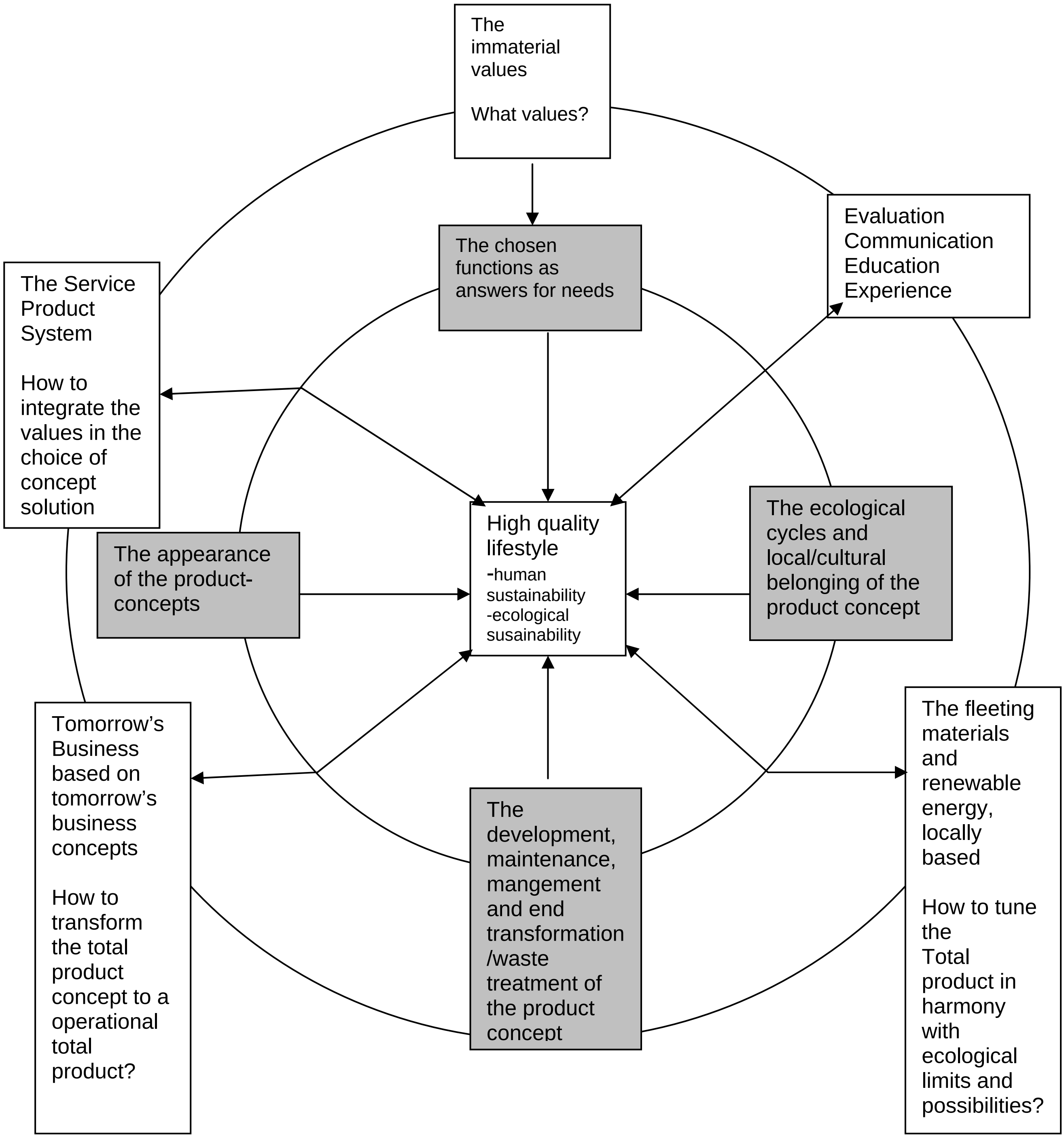


Figure 9 “The wheel of relations” concerning the ecological and human problems seen from the perspective of an industrial designer.

The ecological problems we experience today, and expect in the future, are of very complex character. They are rooted in the human culture and ways of thinking concerning consumption and nature resources and in linear and short time thinking. In other words, the human worldview in some cultures (until now mostly the Western) is not considering the consequences of own actions in a long time perspective. With this starting point it is hard to see how a small fraction of the situation can be sourced out and be made into research objects, and give valuable knowledge, following the scientific methods of research.

In design and production of products today it seems to be important what values the designer and other people in the design process are implementing in the choices made in the different steps and phases (Figure 9).
These values are assumed to be somehow transferred through the product lifecycle, to the end-user and hopefully affect the life style of the user and thereby the life cycle of the product.

Other designers are inspired by philosophical concepts as well. Alain Findeli (1995) is presenting Moholy-Nagy's interesting connection of influence from researchers in the Vienna Circle (Wiener Kreiz), promoting logical Positivism, the biologist and theosophist Raoul Franancé, and further the pragmatic philosopher John Dewey. The methodology of Moholy-Nagy is, however, of phenomenological character because the synthetic stage of the design process is preceded by intuition. This is necessary because the complexity of the problem is beyond the reach of the sequential and verbalized process of the intellect. This was claimed two generations before, when systems theory and phenomenology were introduced as essential paradigms of contemporary science.

Findeli is presenting two major philosophical systems which he claims are implicitly the background of Moholy-Nagy's intuitively developed curriculum. These systems are Goethe's epistemological system, introducing the humanistic anti-materialistic perspectives, and the methodological aspects from John Dewey's pragmatic philosophy. The intuition as a tool in comprehending natural phenomena was defined by Goethe as contemplative judgment (Anschauende Urteilskraft). Moholy-Nagy applies clearly this method to his design process and demands teachers, who are familiar the strong intuitive and rather artistic process. From Dewey the book Art as experience (1934) was a part of the reading list in the Product Design workshop in the New Bauhaus in Chicago (see ch. 1.2.1.) Dewey has a relativistic and phenomenological basis and promotes that no human phenomena can be evaluated without its general physical and social environment. The students were in this context going through a process which was intended to raise their ethical and social awareness, through the continuous work following the cyclic process of refining crude material.

VII. Interview guides and motives

Main content of Interview guides for participants in the pilot project I and II

What do I want to know:

- How the participants experienced the process in terms of project structure, goal and achievement, and time spent in comparison with own ambitions on behalf of representing a company.
- How the participants would distinguish this process from the more traditional design work and environmental tasks in their company.
- How the industry can implement this type of working procedures in parallel or in synergy with daily duties and development

Why do I want to know this:

- To evaluate and compare the weight of the time spent on different focus in the project vs the outcome and expectations. This is important in the terms of motivation and further development of the methodology considering setting goals
- To grow the characteristics of the methodology to become more clear for future communication and introduction of the new methodology
- What are the main barriers for implementation today and what are the positive drivers

1How the participants experienced the process in terms of project structure, goal and achievement, and time spent in comparison with own ambitions on behalf of representing a company.

2How the participants would distinguish this process from the more traditional design work and environmental tasks in their company.

3How the industry can implement this type of working procedures in parallel or in synergy with daily duties and development
-what is the main driver for your company to participate in a factor 10 development project?

Main content of Interview guides for design researchers in other fields -“Reality check”

What do I want to know:

- What are the possibilities of implementing the factor 10- design methodology in Norwegian companies today?
- What already existing procedures are useful to broad perspective thinking in product design processes?

Why do I want to know this:

- The theory and pilot study should lead to development of tools which are realistic to implement in some type of design processes in industry today.
-

References

Kvale, Steinar. *Det kvalitative forskningsintervju*.(Original title: Interviews. An Introduction to Qualitative Research Interviewing) Norge: Ad notam Gyldendal 1997

(test interview)
System thinking

1. Do the designers have experiences which can be transferred to design of more holistic systems of products?

1.1 Parallel design of products
1.2 Total concept focus
1.3 Product families

1.4 Do you see from your perspective other advantages in working from a system perspective? Eg. user needs. Have you experience from this?

Vision

Do you create visions for your projects next to goals (research and design projects)?
Do you have methods today to secure the visions of the solution through the design process?

2. Will it be possible to secure the ecological and sustainable ideas through the concept?

2.1 Main ideas carried through a process today
Main drivers to secure ideas (next to economy)

2.2 User perspectives

1.Creating a Vision
- How is the vision created?
- Analyses and research
- Setting a goal
- Creative processes
- What are the characters of a strong vision with high durability?
- Is a common ownership important?
- How is a common ownership created towards the vision?

2.3

Research projects vs design projects

1. There is a need in many projects to have a combination of security and uncontrolled idea generation for innovation.This can be seen as a more research based process in combination with the conceptual and creative phases in the design process.

1.1 How is your experience with companies introducing longer phases of deeper research?

1.2 How is this combined with the work of the designers?

New design –

3. How are the conditions today for adapting a broad thinking methodology?

3.1 Strategic planning

3.2 Innovation as a goal for the design process, why

3.3 Long term thinking

3.4 Use of methodology

3.5 Type of methodology and methods in design

3.6 Project planning

4. Is it possible and desired for the designer to become the hub in a design project, connecting different companies and stakeholders?

4.1 Decision making, based on what

4.2 Empowerment to the designer, consequences

4.3 Co-operation with designers in other companies

Interviewguide - Case study Lillehammer '94

What do I want to know:
How the Vision for the games was created and what where the main drivers for cooperation and communication in the complex design project.
Can these procedures and mechanisms be translated to a factor 10 design project?

Why do I want to know this:
To understand the mechanisms in this case to create a basis for a common vision. To reveal the driving forces which mobilise a number of stakeholders towards the common vision. This knowledge is important in the construction of a new design methodology for factor 10 development.

1.Creating a Vision
- How is the vision created?
- Analyses and research
- Setting a goal
- Creative processes
- What are the characters of a strong vision with high durability?
- Is a common ownership important?
- How is a common ownership created towards the vision?

2.Drivers
- Commercial drivers – was this project unusual considering the economic drivers
- What other drivers where of high importance?

3. Holistic results
- How did the designers respond to the design program in order use it for concrete design projects?
-What are the success criteria for a holistic result:
-clear vision
-strong leadership
-design program and manual
-intuitive and sensitive designers and project leaders
-systematic decision making
-regular and clear communication
-strong individual ownership to the total result
-Did the designers develop special methods?

4. Future holistic projects
- What do you see as critical in order to lead this type of processes in cooperation with different companies?
-Could a single company be in charge of this type of process? What would have to be characteristic for this company?

5. Design and environment
Your process in LOOC did not include any concrete project cooperations with the department of environment. Are there special reasons for this?
-possible areas would have been internal “green office”, reuse of elements, product service systems for the event (food service, equipment in the arenas etc), buildings, temporary and permanent.
-how did you evaluate concepts as environmentally friendly?
-how did you evaluate your materials and processes?

VIII. Interview transcription and coding; a sample

Each transcription became documents of 15-20 pages text written in tables as following. The coding was executed by hand and marker, to be prepared for further analyses and translation.

		videre, enda videre...
		I: Ja, det er interessant med den der prosessen....
Project management Human process	Planning Motivation	LVK: Men om man også kunne møtes oftere...det ville også vært bedre, men man har jo bare en viss pengepott her å bruke av, og de involverte bedriftene som yter egeninnsats de har jo også begrenset med tid i forhold til hva kanskje de føler får utav det, det er jo også noe, hvor mye *vil* de involvere seg iforhold til hva de føler de får ut av det.
Project management	Ownership	I: Så kanskje et sånt prosjekt skulle vært enda sterkere forankret i bedriften, sånn at de som deltok fikk mer tid tilgjengelig, at det ble bevilget mer tid for dem, eller større forståelse for at de skulle være borte tre-fire dager, så bedriften igjen skulle få noe tilbake?
		LVK: Ja, det kan jo hende at det faktisk ville latt seg gjøre, allerede før, det vet jeg ikke om prosjektledelsen har diskutert, og prøvd, eller prøvd på......Det er jo oftest slik i prosjekter at de involverte har dårlig liten tid. Men er egeninteressen stor nok så kan man jo bevilge seg den tiden.
	Characteristics to process	I: Ja, nemlig. Men det har kanskje litt med hvordan man organiserer det, om man tar det samlet over flere dager, eller sprer det utover (LVK : Ja) Men kan du si litt om...hva vil du karakterisere som typiske trekk for den her prosessen som er anderledes enn ved de prosessene du har vært med i før? –eller prosjekter....
Human process	Working method	LVK: Ehm... ja, det at vi startet med uformell setting ved å ha slike helgesamlinger ute på en hytte ute i skogen, det har vært veldig bra. Ja, i forhold til å ......, da løser man litt mer opp enn i møtesetting, og får fram mer kreativitet, tror jeg, og flere sider av saken, ja, det skal jeg ikke si for sikkert (uklart) slik føltes det hvertfall. Og det føltes veldig....ja, på en møte så blir det litt rekreasjon samtidig, selv om det var jobb, jeg tror at de fleste, eller mange følte det på samme måte, at det var ikke noe slit, det var moro samtidig. Iforhold til at det kanskje kan bli mer formelt og mer stivt rundt et bord på et kontor setting. Ja, det er hvertfall en viktig forskjell.
		I: Hadde det det noe å bety for tankesettet, eller var det på en måte noe....?
	Communication	LVK: Ja, det tror jeg. Man blir mer like, likeverdige partnere. Det blir mer akseptert at alle involvererer seg på måte og istendenfor at det fort kan bli rundt et bord at det er en som snakker veldig mye og har høy røst, og er kanskje eldst......Altså det blir et hierarki, ofte. Eller det kan bli det. Men i en sånn setting så blir mer like like, og det blir enklere å være der på likt grunnlag. Vi hadde også med oss studenter for eksempel. Professorer, studenter og forskere, og høyskolelektorer, og mye forskjellig. Ja, den psykologiske faktoren der følte jeg var viktig og bra for et sånn prosjekt.
Management	Planning	I: Hva med, ja, målsetting og arbeidstid, og arbeidsmåte iforhold til målsettingen, føltes det noe anderledes enn andre prosjekter du har gjort?
		LVK: Nei, det tror jeg ikke.
		I: Så selv om det var på en måte et faktor 10 prosjekt så var liksom gangen i....proseessen føltes ganske sånn kjent?
Human process	Working method	LVK: Ja, det vil jeg si så, bare at måten vi gjorde det på var forskjellig. Spesielt med de helgesamlingene som vi hadde. Men man så jo på det som et prosjektmøte hvor man skulle diskutere og komme et steg videre, som man gjør i andre prosjekter også. Gjerne bare på en time eller to....(he, he) så sånn sett så.....
Methodology	Analyses	I: Ja, men når du samlet inn data, så samlet du inn for mange forskjellige produkter, og deres forskjellige livsløp da. (LVK: ja) var det anderledes enn måten du har samlet inn data på før....?
	Communication	LVK: eh....nei, det var ikke anderledes.... Jeg tenker om det kanskje var lettere å få inn data fra de som var med. Det var det nok. Jeg måtte også få inn data fra mange andre, som ikke var med i prosjektet i denne omgang. Det opplevdes som vanskeligere. Ja,.....
		I: Men var det fordi at de ikke visste helt hva det her skulle gå til?

IX. Interview translation from Norwegian to English; a sample

The total document of translated material has 22 pages, and is representing main issues from each respondent in the different areas of discussion. The total document is structured by the coding system of macro and micro clusters. (coding scheme ch. 5.7.2)

	Symbiosis: design and research A1:The researchers within cognitive psychology can cooperation with designers test more theories and research questions on fictive concepts through the use of models and mock-ups. The play with the future and the non-existing has been introduced in a higher degree through the cooperation between designers and e.g. cognitive psychologists. New concepts criticised by designers have also lead to new type of research and company awareness. The high-tech solutions are also promoting deeper research on what is appropriate use of technology in human interaction considering the limitations of human capacity and real human needs. This is often done by the larger companies. It might be a misunderstanding by the smaller companies that research will always cost too much money (ref. a research done on BI considering testing web pages) A2: Important knowledge concerning the communication between the end-users and the production company can be revealed through certain research methods used by designers on a strategic level. Trend analyses and Future scenarios are translated by designers into visual representatives and used for discussions about the company profile and product design strategies. B2:The respondent is suggesting a looser attitude, not to be so business minded in this type of projects, not all activities have to be so time efficient, and focused on short term results. Business can learn from research and research can learn from business: more action, and more doing instead of analysing. Something in between might be good, and that might be the result when the parties meet and work together. It is two totally different worlds. B3: In practice these processes can go very slow, most employees are very occupied with tasks of the day. In this setting it is very good to have another arena with people who are willing to stretch longer than changing some steel components to aluminium. To visualise the scenarios and conceptual ideas is good. **The visualisation is bringing the material closer to the readers and avoids the associations of space shuttles to appear once the word future is mentioned.** C2: The respondent was a part of a design research project in the beginning of the 80's . He asked the Tele company in Norway about screen graphics and user interface. It ended in a research project that he executed through a year. Many different Norwegian companies where involved.
Human processes	**Communication** **-strategy in project** A2: Communication is a keyword in many perspectives in the creation of new solutions. A clear company design profile have an internal communicative affect on the employees and their loyalty and pride of their own company, as well as an external importance concerning the positioning and reactions in the market. The communication in a (design strategic) process of decision making can be supported by visual models or visual representatives. The designer's communication abilities on the other hand are crucial to what position and tasks the designer may take, and on what level in the company. A1: Different design methods can also be used especially for communication between the team members to make clear the vision and scope of the project. B1: The process with discussions and communication both in "pictures" and strategies has been very inspiring. This was the most important part in the the factor 10 project. **The characteristic of the project was the informal atmosphere which made all participants equal partners in the discussion.** The working method, sitting in a cottage, was promoting all participants to get involved and destroyed

	typical hierarchic structures. It was easier to receive data from the companies which where commited to the process than others. This is a general experience though. The pedagogic aspect is important "why should we contribute to this project?" The sales document of the project might given strength to the total communication in the group also "What is the vision - Why are we sitting here?". A vision can represent a short but important message of the project content, it can be easier communicated than a long report. B2: The factor 10 terminaology might need to be defined more concrete and related to the next step in the development today. The definition of factor 10 is hard to remember and understand for most people, assumed the respondent. The communication about environmental issues internal is hard to maintain if there is no supporting system in the organisation itself. A smaller pamphlet "selling" the project would be a good tool for discussion. The project team could perhaps meet again to finish this type of brochure. The practical example from the company of the respondent could be used also in this "sales document". There is also a challenge in communicating with the end-user of the products from the company. B3: The discussions have been very important and useful. The knowledge should be spread to the directors though, these should have been involved. The communication route in-house prevents you from knocking on the door of the chef executive, so the information does not reach the right people. The respondent is now sitting in the board of director. She might therefore come in position to front some of the actual issues concerning factor 10 and the company strategy. The barriers are probably not in the technology, but in the organisation and communication. It is very hard to sell inn the environmental issues to someone who are not in this state of mind. It could be a possibility to present some of the factor 10 ideas on the seminars for leaders in the company. About 80 persons from the cooperation are then presented from all the countries in where they are present Not all people are open for the factor 10 concept. The message has to be presented with arguments from their perspective. The presentation of the work must be presented in a short version. CEOs do not read more than 3 pages. It must be exciting to catch their attention. But even the company representatives who participate at the factor 10 seminar, have understood the concept. The message easily becomes defuse, and too far away in time, and prevents people to see the threats. It must be explained very concrete the reason behind the issue; why reduce the impact by 50% and why think in long terms, perhaps 40 years or more. B4: The respondent had some other ambitions about including daily activity in the project. More openness concerning publication of works and inclusive attitude from the project leader. This should have been mentioned on one of the seminars. The initial briefing could have been somewhat clearer in terms of the background for the main project. In this connection the reports can be made more "reader friendly", both in terms of length and style of writing. In future projects and commercial networking, the themes of discussion should be clear on forehand. What information is open and what is not. What is public. The company has now introduced a system where all employees may come with ideas for evaluation. An electronic system is receiving the decription of new ideas and is then bringing the material further to correct persons and boards for discussion and evaluation. This clear communication system is reducing the time from idea to real product on market. C1: The respondent had the understanding of the design director spending much time communicating the design tasks, the vision and themes internal in LOOC. He communicated the thoughts and ideas, which where underlying the design programme, and not less, that it (the design programme) should be followed, this was the most important. He spent a lot of time on this, and we prepared the material for promotion. There were, however, a lot of things that the team of the respondent could not control at all. They had provided a box of tools , though. When the main concept was designed, every department internal in LOOC was given a presentation of how the design programmes could become. The design team presented all the basic elements, from the logo and further on, -for about 10 departments. It was very well received by all departments.

	For four different design bureaus to function well in this type of cooperation, the most important was to be open for thoughts and ideas. The respondent experienced it this way, it was a sketching process where one step at a time was taken and results fell in place. C2: The respondent managed to bring the minister of culture, almost as an alibi, to announce the new mascots for the winter games. There were a lot of critics towards the spending of money for the Olympics the first years of planning. However when the design team presented the design program and the pictograms – this is it – it became a success. The newspaper wrote in the leader “Now we have complained enough concerning Lillehammer’94, but here is something to be happy about.” So the design department came in a positive spiral. The respondent made a list of the most important stakeholders. Then he came to Øyer County to make them motivated, he had to use a different approach of communication towards Coca-cola. He used a basic presentation, including scenarios that were made in the first presentation, together with the first design group. They made lots of “dummies” of how things could look like, and sketches. Two slide series that he has shown thousands of times. Then the dummies was exchanged with real things and in the end there was only real things. The management system for the entire organisation with defined goals was a must for everyone, it did not help the design chief however, you would never managed to get Øyer County or Coca-cola Company on your team if you just write these kind of documents. It was somehow a way to speak both to the hart for common goals and winning together. Petter Rønningen had an introduction course for all new employees, like real companies have. And then the respondent was allowed to come and have a mini presentation; this is the design program, why it was the way it was, and how it became like that. The president of the winter games could ask the respondent to make his design presentation in the beginning of a difficult meeting with outsiders, to make people in a good mood. Design can be used for do many things.

X. Degree of freedom and extent of a design task

	Product (physical)	**Product and system**	**Product, service and system**	**Service and system**
Redesign	Need and demands are satisfied in the same principial way, but with with few small and simple incremetal changes of the product which remains in the same product type (use of same (support) system)			
New design	Need and demands are satisfied in a new way by introducing a new principal solution.(use of existing (support) system)	Need and demands are satisfied in a new way by introducing a new principal product and system solution.	Need and demands are satisfied in a new way by introducing a new principal product service, system solution.	Need and demands are satisfied in a new way by introducing a new type of connection between service and system containing already existing products.

Table xx The table is grading the different complexity in in design development projects in relation to what part of the solution is demanding a redesign or new design. (Wigum 2003 in Hanssen et al. 2003))

XI. Survey with results from workshop for testing of models, December 2003

Resultater fra Spørreskjema
Erfaringer fra workshop og forskningsfrokost 16.12.2003 ved Institutt for produktdesign

13 besvarelser er innsendt av 14 deltagere – tusen takk! På innledende frokost var vi 16 personer inkludert undertegnede.
I tillegg til avkryssing har veldig mange gitt konstruktive og gode kommentarer i tillegg. Det er med på å nyansere de øvrige svarene, og til god hjelp i videre arbeid med modellene.
Her kommer de samlede svarene for avkryssende alternativ. Totalsummene ved hvert spørsmål kan være mer eller mindre enn 13, da det var mulig å gi flere kryss pr. spørsmål eller utelate å besvare.

Opplegg

Hvordan var din opplevelse av

- Frokost som intro**:**

11 bra **1** unødvendig O hadde vært bedre med felles lunsj istedet
3 viktig for påfølgende gruppearbeid

- Innledende del til workshop:

tidsbruk	**1** for mye	**10** akkurat passe	**5** for lite		
Informasjon	**1** for mye	**5** akkurat passe	**3** for lite	- **3** vanskelig å forstå	O tydelig
Inspirasjon	**5** bra	**6** passelig	**1** lite		

- Workshop

tidsbruk	O for mye	**7** akkurat passe	**5** for lite	
gruppestørrelse	O for mange	**11** akkurat passe	**2** for få	
problemstilling	**3** passelig åpen	**3** for lite detaljert	**2 (+2)** vanskelig å forstå	**3** inspirerende

- Helhet:

Forskningsfrokosten var **12** faglig interessant **11** sosialt interessant/nettverksbygging
O bortkastet tid **1** delvis bra

Av disse resultatene ser det ut til at selve opplegget var vellykket og at deltagerne satte pris på å starte med sosialisering og frokost. Tidsbruken påpekte noen kanskje var litt knapp, men på den annen side bidro det til at så mange hadde anledning til å delta. Utfordringen ligger antagelig mest på arrangøren av den faglige delen og tilpassing av innholdsmengde. Det er forøvrig interessant å se at problemstillingen gitt på workshop opplevdes veldig forskjelig blant deltagerne.
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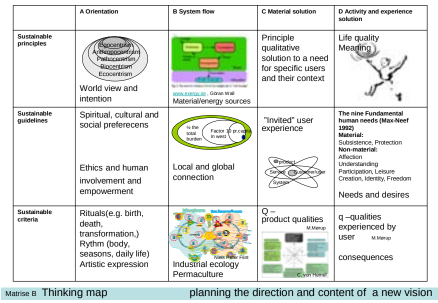
Arbeidet med modellene

Hvordan var førsteinntrykket av modellene?
9 Komplisert
1 Oppklarende
O Banale
1 Frustrerende
11 Interessante
1 Oversiktllige
2 Nyttige
2 Intuitive
O Slitsomme
2 Høy grad av nyhet
1 Lav grad av nyhet
O Morsomme

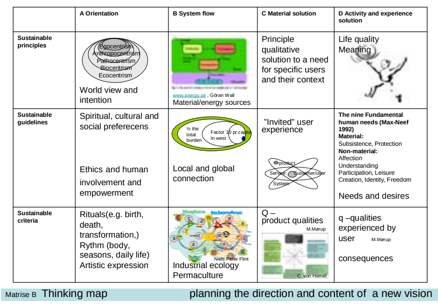
Hvordan var modellene nyttige eller mindre nyttige i de ulike oppgavene:

Oppgave 1: presentasjon av din kompetanse og møte med de andre deltagerne



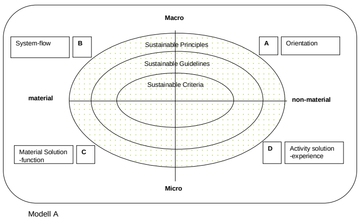
4 Veldig nyttig
9 Litt nyttig
O Ikke nyttig

Oppgave 2: Utvikling av grunnlag for ny visjon



3 Veldig nyttig
10 Litt nyttig
O Ikke nyttig

Plassering av fokus for visjonen

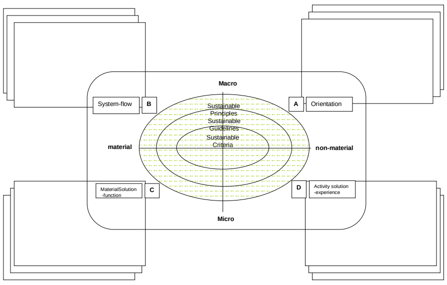


What is the tool Thinking map, Communication and evaluation tool

7 Veldig nyttig
5 Litt nyttig
O Ikke nyttig

(**1** vet ikke)

Visualisering av visjonen



Modell C Communication creating and visualising the new concepts

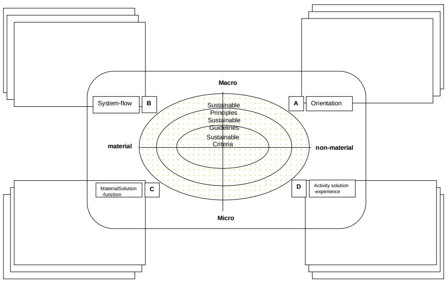
5 Veldig nyttig
3 Litt nyttig
O Ikke nyttig

(**3** vet ikke)

3 Utvikling av nye ideer

Hadde arbeidet med visjon for ny ide, betydning for ideutviklingen?
4 Stor betydning
6 En del betydning
3 Noe betydning
O Ingen betydning
O Vanskelig
O Uklart

Visualisering av nye ideer



Modell C Communication creating and visualising the new concepts

4 Veldig nyttig
4 Litt nyttig
2 Ikke nyttig

4 Evaluering og diskusjon av nye ideer

	A Orientation	B System flow	C Material solution	D Activity and experience solution
Sustainable principles	•What is the intention of the concept?	•System perspectives: How is the flow sustainable?	•Is the main function answering the questions of actual needs and desires?	•Does the total solution seem meaningful to the intended user?
Sustainable guidelines	•How is the acceptance presumed according to social, cultural and spiritual context? •Ethical values: How are the perspectives of the people involved represented, and how are they empowered within the new concept?	•How are the local conditions integrated into the concept? •Can the use of (food and) natural resources, as well as energy and outlet of emissions be justified?	•Is the solution inviting for sustainable living?	•Are the needs and desires basic or substitutes?
Sustainable criteria	•How are daily routine and behaviour affected? How does the concept involve traditions, rituals or sub-cultural specialities?	•What is the basic thinking in creating the cycles of the resources?	•Is it expressed (aesthetics, technology, materials) in an appropriate way?	•How do the final experiences by the user, stimulate senses and satisfy basic needs?

Matrise D Evaluation comparing qualities of early concept ideas and the vision

2 Veldig nyttig
3 Litt nyttig
(1) Ikke nyttig

(**3** Vet ikke/ kanskje)

Generell tilbakemelding

- Gode egenskaper ved modellene

3 Virker samlende for gruppa
7 Gir rom for ulike synspunkter og fagområder
4 Viser sammenhenger mellom ”harde og myke” verdier
1 Fremmer nye tanker
2 Fremmer nye løsninger
5 Inkluderer et mangfold av verdier
7 Fungerer som kommunikasjonsverktøy
11 Fungerer som diskusjonsverktøy

- Svakheter ved modellene

6 Kompliserte å sette seg inn i dem
6 Utydelig innhold
4 Utydelig anvendelsesmåte
7 Krever fasilitering/ forklaring mht bruk og innhold
2 Ulogisk oppstilling av tema
1 Er for ”altomgripende”
O Er for styrende
O Forenkler i for stor grad helhetsbildet
1 Har i for liten grad ”profesjonell” framtoning

- Når (i hvilken oppgave) og hvilken modell synes du fungerte best: (utklipp fra engelsk oversettelse i Excel)

When and which model did you find most useful:	1 Matrix B, presentation **1+(1)**	2 Matrix B Planning vision **4**	Model A Placing Vision **3**
	3 Model C Visualising new ideas **4**	Model C Visualising/ com. vision **1**	4 Matrix D Evaluating new ideas -

- Råd for videre utvikling av modellene

For matrisen var det mange som påpekte utydeligheten av innholdet i de ulike matrisecellene, uklare nivåer og at det var komplisert å sette seg inn i stoffet slik ved første øyekast. Forslag om at deltagerne selv kan fylle ut innholdet i matrisen er interessant, og var også en del av ideen for mer omfattende arbeid med dette f.esk i et stort prosjekt. Det er uansett viktig å ha en retningsgivende matrise å forholde seg til, med eksempler på de ulike nivåene og områdene.
Navngivningen av modeller og matrise ble kommentert som litt ulogisk å forholde seg til.

Sluttkommentar
Denne form for workshop gir gode signaler om svakheter og styrker ved modellene i seg selv, men også vedrørende måten å jobbe med dem på. Noen påpekte også at prosessen på enkelte av oppgavene opplevdes som viktigere enn selve resultatet.
Noen av oppgavene, f.eks evaluering av nye ideer, er det ingen av gruppene som fikk tilstrekkelig tid til å gjøre. Resultatene omkring matrisen for evaluering er derfor ikke særlig retningsgivende, men det framkom noen positive signaler fra deltagere som hadde fått tid til å lese gjennom de konkrete spørsmålene som matrisen inneholder.

Det ser ut til at det er noe forskjell på opplevelsen av modellene etter hvilken bakgrunn de ulike deltagerne hadde. Besvarelsene er i en mer komplisert oppdeling blitt delt inn i fargekoder etter gruppetilhørighet og i fire ulike kategorier med tanke på bakgrunn. Inndelingene er slik:

D: designer eller produktutvikler
I: naturvitenskapelig, samfunnsvitenskapelig eller humanvitenskapelig
DE: designer eller produktutvikler med spesialisering innen økologi/miljø
IE: naturvitenskapelig, samfunnsvitenskapelig eller humanvitenskapelig med spesialisering innen økologi/miljø

Denne workshop'en gir allikevel et for lite grunnlag til å konkludere for de ulike gruppene, da enkelte er representert kun med et par deltagere.

Det ser ut til å være stor enighet om at matrisen og modellen er gode utgangspunkt for diskusjon og kommunikasjon. Videre ser mange ut til å mene de gir rom for ulike synspunkter og fagområder og ofrer like stor del på ikke-materielle som materielle områder. Over halvparten av besvarelsene mener det er en svakhet at matrisen og modellene krever fasilitering. Ved forenkling og tydeliggjøring, vil kanskje dette behovet også reduseres i tillegg til at de blir langt mer anvendelige.

Det var kanskje skuffende å se at så få (1 og 2) mente at modellene fremmer nye tanker og ideer. Det kan kanskje tenkes at i en lenger og mer dirkete og konkret bruk av dem, vil denne egenskapen ved modellene være tilstede.

Kristin Støren Wigum, 13.01.2004

XII. Project progress and activities

Pilot pre-project: April 1999- June 2001
Pilot main-project: Autumn 2001 – June 2003

1999
September: the PhD-project is initiated
Course: The fleeting materials, study of renewable materials; supervised by Christian Thaulow

2000
Course: Eco-design methodology; Hanssen (supervisor), Kviseth, Hansen, Wigum
Visit to Delft: Interview with Leo Jansen at TNO

Course: Eco-philosophy and Design for sustainability; supervised by Martina M. Keitsch
February : Conference article , Zürich

Course: Wood technolohy, supervised by Prof. Birkeland

May: Conference article, Milano

Autumn:
Course: Organisation development and Change, supervised by Olav Solem

2001
Course: Theory of science :Practical research methodology; Lecturer: Linn Mo

July: The final working sketch (5.th version) is made and presented at the department, for discussion

September: Beginning of maternity leave

October: Conference article, Co-operation with Mette Mo Jakobsen, Cfsd, Amsterdam

2002
June: returning from maternity leave

August: Conference presentation and article: Norddesign, Trondheim

September- October: the research questions are fine –tuned

December: the Thinking Model is born

2003
January-May: Responsible of Eco-design course 3rd grade at the Dep. Of product Design Engineering

March: “Pre-disertation” arranged by Programme of Industrial Ecology, presentation of all material

June: Closing seminar for pilot-study, presentation of material

August: Two weeks discussions and work at Cranfield University, UK
Focus: The Thinking Map

August: Accepted, but not able to attend, Conference article: Stockholm ICED 03

October: Two weeks discussion and work at Aalborg University, Dk
Focus: The Methodological Framework, initial phases

October: Conference article : Stockholm

September- November: 8 deep-Interviews are made

November- December: Transcription of interviews

2004
January- February: Transcription of interviews

May: Responsible for two-weeks course in Eco-design, held in Xi’an, China

January- July: Writing the thesis

August: Sending the thesis to the committee