

Environmental improvement through product development

A guide

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Environmental improvement through product development

- a guide



Technical University
of Denmark

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DANISH MINISTRY
OF THE ENVIRONMENT

Environmental
Protection Agency



Confederation of Danish Industry

IPU

This Guide is one of the results of a project funded by the Danish Environmental Protection Agency and conducted in collaboration with the Confederation of Danish Industry (DI), IPU and the Technical University of Denmark (DTU).

We present this Guide, which is based on a review of methods and experiences with environmentally conscious product development in Danish and international companies and on a series of workshops with industrial companies. The Guide is primarily aimed at product developers, as an aid to building environmental thinking into the product development process - and thus into products.

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Introduction

Companies in Denmark and abroad are increasingly working to reduce human impacts on the environment and nature. At the same time, there must be a sustained focus on the creation of value for customers and consumers. This development gives rise to a huge potential for Danish companies to create new business opportunities, where sustainable development and value creation are integrated early into the design of new products and services.

There is a great opportunity for businesses to create a new and positive agenda, where the focus is on all the good that companies can do for the environment, society and economic growth. Such an agenda must, of course, be based on a high involvement of the competencies of the companies' own employees, as well as those of partners in the value chain.

The Danish Environmental Protection Agency and the Confederation of Danish Industry are cooperating to promote and aid the establishment of such a new agenda. We place our focus on how products and services can be designed so not to harm humans, the environment and nature.

With this *Guide to environmental improvement through product development*, we take the first step in this collaboration. The Guide gives inspiration and a stepwise approach to actively integrating environmental considerations into companies' design and product development processes. The Guide is intended primarily for product developers who have the task of building environmental thinking into the product development process. However, environmental staff, industrial designers, manufacturing staff and others can also benefit from reading the Guide.

The Guide is based on a review of the environmentally-oriented methods used and product development activities carried out in Danish and international companies, as well as on experience gained through a series of workshops with Danish companies.

The Guide has been created by the Technical University of Denmark (DTU) and IPU Product Development, in cooperation with the Confederation of Danish Industry and the Danish Environmental Protection Agency. Development of the Guide was financed through the Danish Environmental Protection Agency.

We hope you will be inspired!

A guide for product developers

How can one adopt a radically different approach to product development and manufacture, in order to achieve significant environmental improvements?

As environmental impacts occur at various stages in a product's lifetime, it is important to adopt a so-called *life cycle approach* to product development. This Guide is therefore based on a typical life cycle view of products, with a particular focus on whole-life thinking, already from the very early stages of product development.

The Guide presents an approach, which is targeted at product developers and product development teams in companies. Use of the Guide will aid environmental thinking in product development. The approach consists of seven steps, which demonstrate how to tackle the environmental challenges in product development.

The Guide will help to create an overview and consensus in the product development team, regarding environmental efforts to be made. Furthermore, it will inspire the process of prioritisation, with respect to environmental improvement goals for product development.

By following the Guide, you will be led through a systematic and creative process, where you will identify your company's potential for creating synergy between environmental improvement and business creation.

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Accept the environmental challenge!

Taking a systematic approach to understanding where and why a product has environmental impacts in its lifetime also leads to competitive advantages for the company as processes and relations become transparent.

For instance, around 90% of the waste that can be attributed to many of the products that we meet in our daily lives has been created before the end-user even gets their hands on the products.

There is, therefore, a need to create environmentally improved alternatives to existing technologies, materials and procedures.

The company, its customers and its suppliers should all be made aware of the fact that sustainable development is a collective responsibility, which has consequences for all parties.

Seen from a pure business perspective, there are benefits to be reaped from environmental stewardship. It has been demonstrated, for instance, that environmental thinking in product development leads to efficient products, which are both economically viable to produce, cheaper to operate and maintain and more robust over their lifetimes.

Systematic environmental thinking in product development leads to products which meet the demands of legislation and standards and for which there is growing demand among customers.

By taking a systematic approach to the environmental design task, environmental product improvements can often be equated to increased product quality.

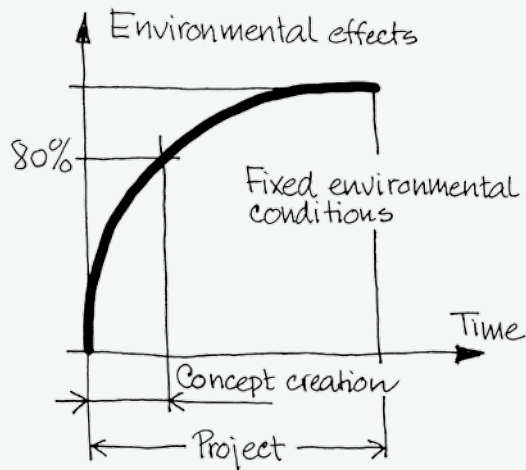
At present, there are numerous examples of sustainable technologies, products and system solutions, which are sprouting up out of industrially-driven initiatives, research centres and universities. A major motivation for these initiatives is the recognition that the goals of environmental and sustainable development can also be considered to be conducive to innovation and business creation.

The individual company, therefore, has a unique opportunity to utilise its access to free markets, innovative staff and potentially willing users, in order to generate significant environmental benefits, which at the same time satisfy users' needs and create a market success.

The product developer has the greatest influence

Environmental impacts are caused in all stages of a product's life, and different products give rise to different types of environmental profiles. The environmental impacts connected to the manufacture, use and disposal of a bicycle, for example, are very different from the impacts connected to a car.

But regardless of the nature, size and time of occurrence of environmental impacts for a product, the vast majority of these have been decided in the early phases of product development.



Approx. 80% of a product's environmental profile is fixed under concept creation in product development

The product developer, therefore, has a great influence on the product's life cycle and also on the subsequently occurring environmental impacts. It is here where materials, technologies and the product's lifetime are fixed. It is, therefore, important that the product developer incorporates environmental considerations carefully and systematically into the development project.

In the product development process, it is necessary to make an estimation of which environmental impacts will be most likely to occur throughout the course of the product's lifetime. It is important to create a dialogue between all departments and functions within the company so as to ensure that optimal environmental decisions can be made early in product development. And it is essential that environmental stewardship become an integral part of the product development process, on a par with considerations such as cost, quality, Design for Manufacture, and so on.

By taking a systematic and creative approach to environmental improvements in product development, it is possible to create innovative and radically improved environmental concepts. The involvement of many functions and professions in this process gives rise to multiple viewpoints and increases the likelihood of optimal solutions.

Coloplast A/S - Environment as a global strategy

Coloplast A/S develops, manufactures and markets medical devices and services within three business areas: ostomy care; urology and incontinence; and skin & wound care. Since Coloplast operates globally, the company considers its responsibility for health, safety and environment to be very large.

One of the activities in which Coloplast participates is the United Nations sustainability initiative, 'Global Compact'. As an integrated part of Global Compact, Coloplast focuses on minimising the environmental impact throughout the product development process.

Coloplast's customers are often public procurement functions. Environmental performance has become a crucial factor in the purchasing decisions of certain of these customers. Coloplast sees these customers as being instrumental in supporting the company's work towards developing products with a reduced environmental impact.



Gabriel A/S - Environment as an innovative asset

As a globally operating manufacturer of technical textiles, environment is an important parameter for Gabriel A/S. For this reason, Gabriel has been working with quality and environmental improvement for a number of years.

- In 1991, Gabriel became the world's first furniture textile manufacturer to be quality certified under ISO 9001.
- In 1996, an environmental certification followed, under ISO 14001.
- In 2000, the company carried out a life cycle assessment according to the ISO 14040 standard.
- In 2002, Gabriel received the European Ecolabel for a large portion of its product mix.

On the basis of a continually increasing focus on the use of health, safety and environment as competition parameters within their value chain, Gabriel works actively on integrating new tools into the development process for new products, services and business concepts.



The product's life cycle must be revealed

An important step in the process of systematic environmental improvement is to gain insight into the product's life cycle. By forming a picture of the whole life cycle of the product, we can ensure that each stage in the product's life becomes as environmentally benign as possible. This activity is called *product life thinking*.

Product life thinking involves an active and systematic charting of every product life stage, together with the various stakeholders and situations that the product is likely to meet during its lifetime. This broad approach to product development gives the company important insight into life cycle stages, such as the product's use stage, early on in the project.

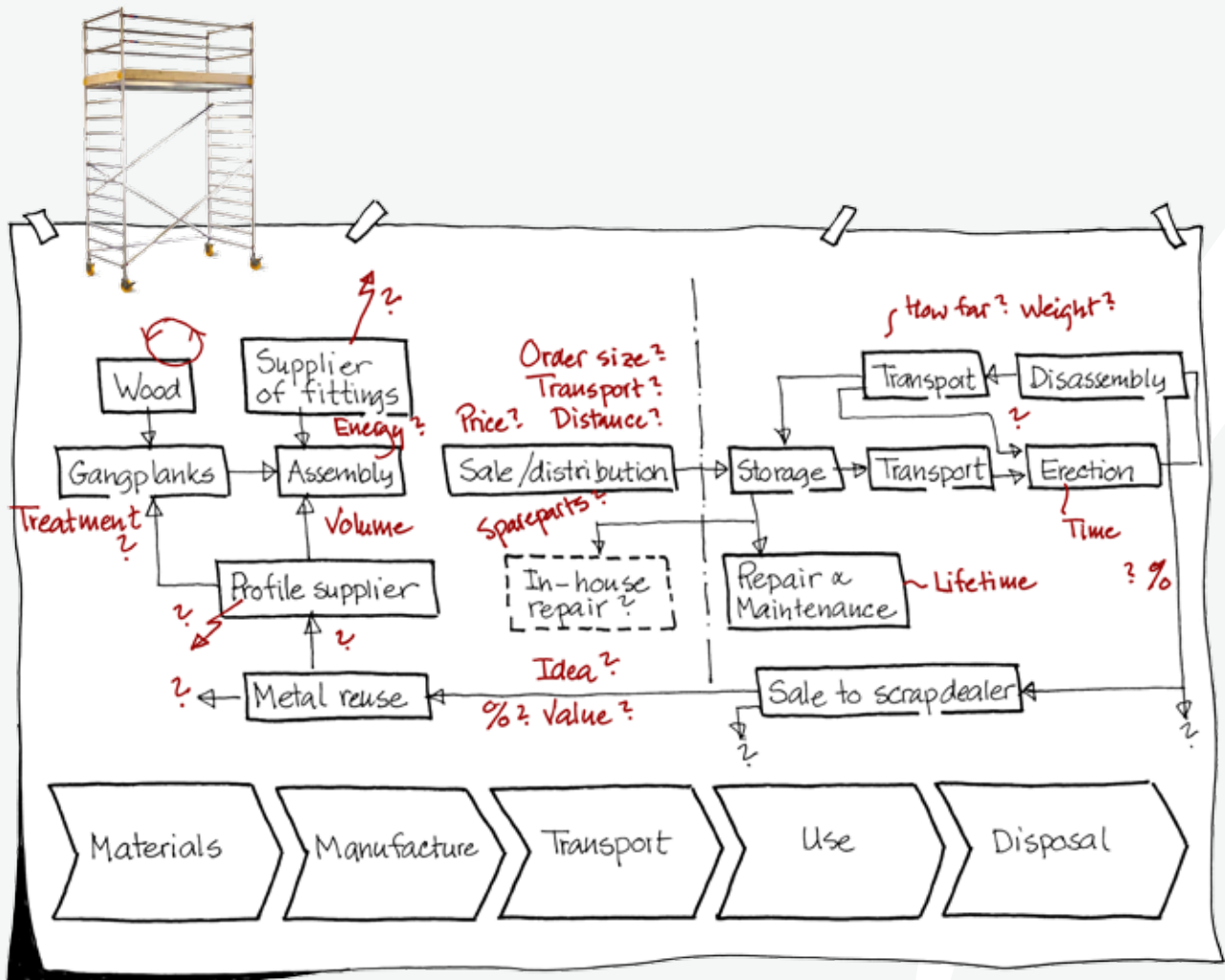
When the product life cycle is revealed to the product developer, it is possible to identify environmental problems and potential solutions for the whole life cycle. But other stakeholders from the company must also join in. As the environmental demands on a company's activities and products increase, product life thinking can be used to ensure that the company's environmental responsibility is integrated into the manufacturing processes, logistics and also the actual use of the products which are launched onto the market. It is obvious that by adopting

a focus on the whole product life cycle, new competitive dimensions or even whole business models can be formed.

In order to spot potential environmental impacts, it is important to visualise the product's life cycle, based on a concept for the various situations and stakeholders that the product will meet throughout its lifetime.

Each product life stage should describe both the product and all related activities in order to create a picture of resource consumption and the root causes of environmental impacts.

**EXAMPLE: MAPPING THE PRODUCT LIFE CYCLE FOR A SCAFFOLD.
POTENTIAL ENVIRONMENTAL CAUSES ARE INDICATED IN RED.**



CASE: COMPOSITION OF AN ENVIRONMENTALLY CONSCIOUS PRODUCT DEVELOPMENT PROCESS

Grundfos Management A/S - In search of a systematic process for environmental improvement

With an annual production of approximately 16 million pumps, production in 14 countries and a commercial representation in 42 countries, Grundfos takes its environmental responsibilities seriously.

Grundfos takes a life cycle approach to product development, which corresponds to the company's "Total Cost of Ownership" (TCO) philosophy. This is important for Grundfos, as the significant improvements that can be expected to be built into a pump lie in the product's operation period. These improvements include energy savings and increased pump efficiency. TCO can, therefore, be used to reveal the pump's environmental profile.

Environmental thinking is not new to Grundfos. The company has experience with many of the tools and methods mentioned in this Guide. From negative lists and life cycle assessments to environmentally responsible manufacturing processes – Grundfos has activities, coordinators and reporting procedures in place throughout the company.

But due to the origin and nature of the environmental considerations, there have been many dispersed and individual development projects, which have only been coordinated in some situations.

In recognition of the need for a more systematic approach to environmental consideration in product development, Grundfos has begun to link the various tools together towards a standardised approach to environmentally conscious product development.

"We knew most of the individual tools already. But the novelty for us was the way in which the tools were organised for the workshop and the way in which the 7-step approach created a holistic view of environmental improvement. We will attempt to integrate the tools in the future, partly through workshops, partly through our product development procedures.

It is of course not possible for our environmental department to follow every single activity or product development project. That is why we need simple tools that can be easily disseminated and that our colleagues will use."

[Helle Nystrup, Senior Environment Engineer, Grundfos Management A/S]



Environmental improvement in 7 steps

WHY A 7-STEP APPROACH?

Many companies that have had environment on the agenda for some years will righteously be able to claim that they have a good grip on the more eco-analytical tasks and on environmental documentation and reporting. But, in contrast, there is often far less focus on the creation of completely new environmental solutions.

The following 7 steps will guide you through a solution-oriented process towards environmental improvement. The 7 steps are simple, inspiring and different from your ordinary product development tasks. The approach creates space for innovation by focusing solely on environmental issues.

GET A GRIP ON THE ENVIRONMENT

The following 7-step approach is built up to help you:

- get an *overview* of your product's environmental effects
- provide *insight* into important details concerning the product's environmental impacts, its use and its users
- create *solutions and concepts* that lead to environmental improvements, and
- create *foresighted proposals* for the creation of an environmental strategy for product development.

THE METHOD BEHIND THE APPROACH

The 7-step approach is designed as a chain of exercises that ought to be completed from start to finish. It is important, for example, that the product's life cycle and environmental impacts are charted, before commencing with the creation of solutions.

The approach requires that a product is chosen in advance, as an object for environmental improvement. The product can be either an already marketed product, which will serve as a reference product, or a product that is currently under development. The first case is the easiest, as it is easier to identify data about the product's life cycle.

The first 6 steps of the 7-step approach isolate the environmental task and focus on identifying environmental effects. Subsequently, improvement proposals are created. Step 7 provides a framework for an action plan and the basis for systematic integration of the proposed environmental improvements into the product development process.

- * Try in each step to define five key environmental priorities that later can be used to begin a final prioritisation!

The seven steps towards environmental improvement





"Environmental accountability has been a core value in the company for a number of years. Integration of environmental, health and safety considerations is, therefore, carried out in collaboration with our customers. In the future this will be achieved through an increased focus on the "cradle-to-cradle" principle.

It is an easy choice for the user. Most of Gabriel's upholstery fabrics are either labelled with the European Ecolabel or the ØkoTex label."

[Anna Fricke, Gabriel A/S]

WHO SHOULD PARTICIPATE?

The target audience for this approach is all the staff who play an active role in the areas of the company, which may be linked to the product's environmental impacts.

It is best if the participants represent a wide range of disciplines, from mechanical engineers, through environmental specialists, industrial designers and materials specialists, to the factory manager.

PREPARATION FOR THE APPROACH

The approach is executed as a physical meeting, which continues for at least one working day. In addition, sufficient time should be reserved for preparation and follow-up work. Active participation from the delegates is a must. Reporting is carried out as part of the process and environmental improvements are created as the principal outcome.

The following considerations will contribute to a successful workshop:

- It is very important that the approach be thoroughly prepared. Each step should be carefully reviewed in advance so as to ensure the methodology and the necessary practical preparations.
- Participants should prepare themselves by collecting as much knowledge about the product

as possible and should be able to describe the product's life cycle, including development, materials, manufacturing processes, transportation, use/operation and disposal.

- A coordinator must be identified for the approach (either the company's own environmental champion or an external consultant). The coordinator organises and facilitates the process and motivates the participants to come prepared for meetings.
- At least two examples of the reference product should be provided; an assembled and a disassembled one (if the product is suited for this).
- Prepare a working space so as to enable and encourage group discussions – and with plenty of wall space for posters.
- A series of posters should be prepared, to facilitate the process and ensure reporting after each step.
- Create groups of up to 7 people. If there are more than 7 people, then create more groups, which can compete against each other for the good ideas!

CRITICAL QUESTIONS

Each step in the approach concludes with three questions, which serve as an indicator of where your environmental focus ought to be for this step. If you can answer all questions in the Guide, you are ready to create concepts and a strategy for the environmental improvement of your product.

Step 1: Describe the use context

As the very first exercise, it is important to reach a common understanding of the product and its value contribution during use. This provides a common starting point for discussions about the environmental improvement possibilities for the product, which you will need later in the process in order to create product alternatives. It is important that the product alternatives meet the same customer requirements. Redundant product attributes should be considered as waste, both from an environmental and a customer perspective.

Step 1 is, therefore, intended to produce a description of the product's functionality to the user. This description provides the benchmark for all subsequent decisions and can also be used when, for example, alternative concepts are to be compared.

The use context can be described by answering the following questions:

- What should the product be used for?
- What does the product do?
 - For whom?
 - How long?
 - How often?
 - Where in the world?

"What should the product be used for?" leads to a description of the basic task that the product must carry out for the user.

"What does the product do?" allows for a description of the product's functionality, including the technological principle and the features that the product must possess in order to deliver the service to the user. Sub-functions may, for example, be "to stick to the skin" or "to turn electrical energy into rotary motion".

"... For whom?" leads to a description of the main user or user group.

"... How long?" and *"... how often?"* lead to a definition of the time frames and use patterns in which the product must operate.

"... Where in the world?" leads to a definition of the geographical area in which the product must operate and probably will be disposed of.

All in all, these responses lead to a clear description of the product in the form of the *value contribution that the product delivers to the user*.

STEP-BY-STEP APPROACH:

- Write the questions on a large piece of paper.
- Answer the questions in your group, based on your knowledge of the product and insight into users' use of the product.
- Some of the questions can be answered by looking at the product specification (or the business specification, if the product has not yet been developed).
- The exercise is complete when the group has obtained a detailed picture of the product's functions and *raison d'être*, as seen from the user's viewpoint.

WHY CARRY OUT THIS EXERCISE?

Despite the fact that all group members already have their own understanding of the product, its use and use context, it is beneficial to carry out this initial discussion of the product's use context in order to agree on a common frame of reference.

There are often several versions of the product and various markets (possibly worldwide). It is therefore important in this initial exercise to *define a typical product*, to be used for the rest of the process.

It is crucial that the answers to the six questions in this step form a documented description that the project team agrees upon, and which is sufficiently detailed to allow comparisons with the alternative concepts later on in the process.

Critical questions...

1. Where in the product's life cycle do you see environmental impacts?
2. What is it in the use of the product that creates environmental impacts?
3. Can the product's environmental profile be justified when compared to the actual value it provides to the user?



"Environmental thinking is a necessity for Fritz Hansen, as this has become a demand of our customers globally.

Environment has been in focus periodically over the past 20 years. But now we can see that our customers are also beginning to systematically integrate environmental issues and demands. Many companies in the furniture business have, for example, begun to operate with so-called Environmental Product Declarations, which are based on international standards. This shows a tendency towards an integrated approach to environmental reporting and the use of the environment as a competitive parameter towards customers."

[Louise Them Kjølholm, Fritz Hansen]

Step 2: Create an overview of the environmental impacts

In this step, you will create an overview of the product's life cycle and all significant environmental impacts.

A product life cycle typically consists of five main stages:

- **Raw materials** includes materials extraction and manufacturing (e.g., plastic granules from crude oil) and semi-finished products (e.g., steel profiles from iron ore), etc.
- **Manufacture** includes the purchase of components, plus the manufacturing and assembly processes, both in suppliers' and in in-house production facilities.
- **Transport** covers the entire logistics chain, from suppliers to the end-user and beyond, including distribution activities by ships, trains, planes, trucks, vans and cars.
- **Use** includes the actual usage and possible ancillary products that are necessary for the product to perform its function (e.g., paper filters for a coffee maker). The use stage also includes installation and possible maintenance activities.
- **Disposal** includes reuse/ recycling, incineration and landfill. The actual distribution of these disposal options depends on many factors, including regulatory requirements where the product is disposed of, who disposes of the product (an individual or a company), etc. It is obviously difficult to predict how the product will be disposed of, as this stage is typically far in the future.

STEP-BY-STEP APPROACH:

- Draw five boxes that correspond to the main product life stages on a large piece of paper.
- Carry out a brainstorming exercise in which everyone in the group writes all relevant environmental impacts that they can think of. Organise these environmental impacts in relation to the five product life stages.
- Write everything you think of, regardless of whether you know that an environmental impact is relevant for the product, or whether you *just have an idea* about its relevance.
- Use post-it notes, as these will be moved around a little later. Write only one environmental impact per post-it note!
- The exercise is complete, when the group cannot produce any more ideas.
- Tidy up the poster by removing any duplicates.
- Reflect on:
 - What surprised us?
 - What can we not allow ourselves to accept?
 - Where are there clear problem areas?

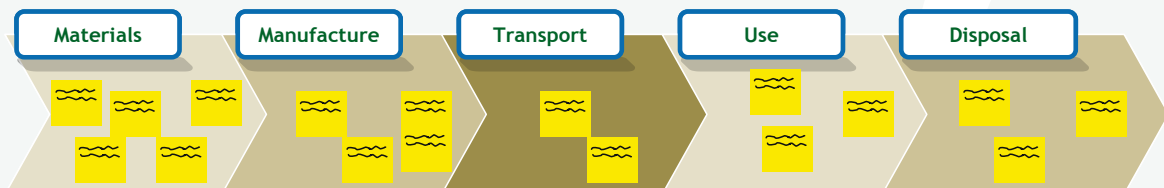
WHY CARRY OUT THIS EXERCISE?

This exercise is carried out as a brainstorm, in order to allow everyone in the group to contribute with their own experiences and insights. It will quickly become apparent that although each individual group member did not have the total overview of all of the product's environmental impacts, the group as a whole could quickly create a fairly complete overview.

When you subsequently look at the product life résumé that has just been created, various patterns can be identified. Maybe one particular product life stage is dominant, as it clearly contains the vast majority of the environmental impacts?

On the other hand, some product life résumés may represent a more or less even distribution of environmental aspects, across all life cycle stages. Maybe a particular part of the product (e.g., “the battery”) appears many times, and thus appears to be worth focusing on.

Since the product life résumé shows the environmental aspects distributed over product life stages, it is easy to quickly *identify environmental focus areas*.



Case example: Environmental focal points for Grundfos

The entire use stage of a pump's life cycle is an obvious environmental focus area, as this stage is energy-consuming and typically lasts for many years, during which the pump runs around the clock. A small improvement in the pump's efficiency will, therefore, create great benefits over the lifetime of the product.



Case example: Environmental focal points for Fritz Hansen

During a workshop with a lounge chair, furniture manufacturer Fritz Hansen A/S found that the entire use stage of the product's life cycle did not contain environmentally critical aspects. At the same time this was identified to be by far the longest stage of the chair's life cycle. Based on this recognition, the participants chose not to focus on the use stage, but instead to look in detail at the other product life phases – in particular, the materials stage.

Critical questions...

4. Where in the product's life can you see environmental impacts?
5. What functions are related to the product's environmental impacts?
6. Does the customer know what environmental problems s/he is buying?

Step 3: Create your environmental profile and find root causes

Following the creation of an overview of the product's main life stages and environmental impacts in Step 2, this step will lead you through an organisation of the environmental impacts according to their type. Subsequently, you will make a note of the possible causes of the environmental impacts' emergence.

The idea here is to create a more transparent picture of the physical relationships that underpin each environmental focus area. A number of focus areas will then be prioritised, based on your consideration of the need for action.

The already identified environmental impacts will now be organised into one of four categories: **Materials**, **Energy**, **Chemicals** or **Other**:

- **Materials**: This includes resource and disposal aspects of each life cycle stage, i.e., whether a material is based on a scarce resource, whether it can be easily recycled, or whether it must be landfilled, etc. Remember also to consider whether ancillary materials are used, particularly in the use phase, such as paper filters for coffee makers.
- **Energy**: This includes energy sources and energy aspects in the product life stages. There can, for example, be large differences

in energy consumption for material processing, depending on whether one takes new or recycled raw materials into consideration. Remember also to consider component suppliers. The transport and use-related energy consumption is also recorded under this category.

- **Chemicals**: This includes chemical consumption and chemical-related emissions of each life cycle stage, such as toxic chemicals used in manufacture or in the materials.
- **Other**: This category includes all other aspects, that one has chosen to consider. For example, health and safety in own (or suppliers') manufacturing plants, aspects related to Corporate Social Responsibility (CSR), or general economical concerns.

This categorisation of the environmental impacts is created in a so-called **MECO-matrix**.

STEP-BY-STEP APPROACH:

- Draw a MECO-matrix directly under the product life résumé from Step 2. The MECO-matrix should be a 4x5 matrix with space for the post-it notes, which are currently distributed on the product life résumé.
- In dialogue with your group, move the post-it notes from the product life résumé, down to the MECO-matrix. Consider each environ-

mental impact in turn, placing them in the most relevant MECO-field.

- If an environmental impact covers two or more MECO-fields, copy the post-it note and then place one in each relevant field.
- The first part of this exercise is complete when all post-it notes have been moved down to MECO-matrix.

WHY CARRY OUT THIS EXERCISE?

In principle, you could have started the whole environmental profiling process by filling in the MECO-matrix, i.e., skipping steps 1 and 2. But

experience shows that there is a tendency to try to fill the entire MECO-matrix, even though there may not be relevant environmental impacts in every single field of the MECO-matrix.

If the product's use context has not been previously discussed, and if the group has not first had the opportunity to carry out the slightly more unstructured exercise in step 2, confusion may arise with respect to where the environmental impacts actually are in the product.

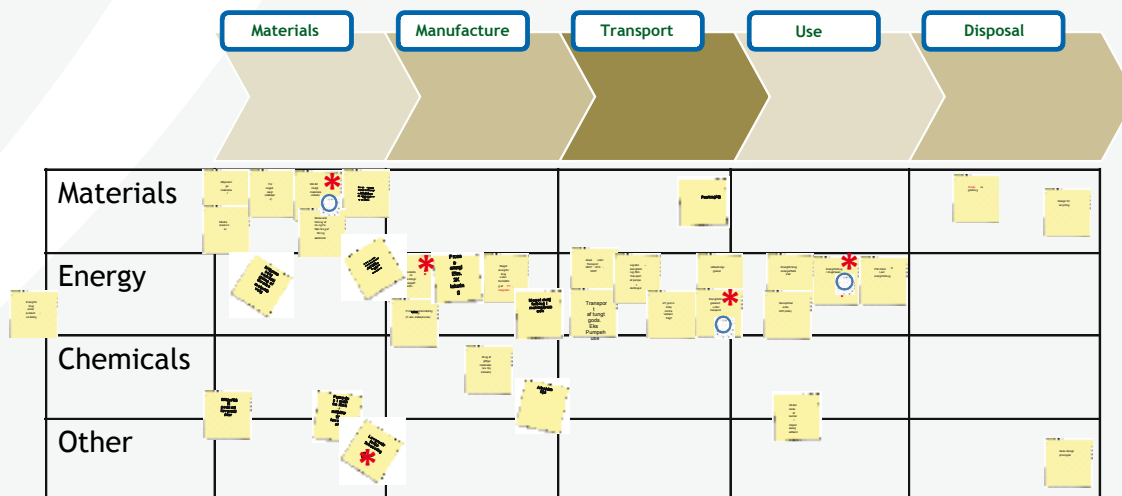


Figure: MECO-matrix and product life résumé with environmental impacts and '**' prioritised environmental focus areas

Finally in this step, you must select the most important environmental focus areas revealed by the MECO exercise.

STEP-BY-STEP APPROACH:

- Discuss the MECO-matrix in your group and gather certain environmental impacts together, if strong relationships are apparent, within each MECO-field.
- Identify the most important environmental focus areas (choose your top 5) by drawing a '*' on the relevant post-it notes.
- This part of the exercise is complete when the group has agreed on a prioritisation.

WHY CARRY OUT THIS EXERCISE?

You now have identified the first five environmental focus areas, which should come out of this 7-step process. The aim is not merely to select five focus areas, but also (and this is just as important) to provoke a discussion in the group about the importance of prioritising the environmental task.

The MECO-matrix can be completed in many different ways:

- *qualitatively, i.e., with text and/or symbols*
- *quantitatively, i.e., with figures, for example, raw material weights in kg and energy in MJ, or*
- *with a mixture of both.*

The matrix can also be completed for one product alone or as a comparison of two alternative products, where one only highlights the differences between the alternatives.

"The MECO exercise gave a quick and clear picture of where to focus. It fits well with our way of working. The exercise gave a good overview and helped us identify how a little effort could positively affect many products."

[Jes Faltum, Lego Group A/S]

The MECO tool and the strategy wheel worked well together to help us visualise the areas we should focus on.

[Louise Them Kjølholm, Fritz Hansen A/S]



Critical questions...

7. Are your product's main environmental impacts to be found in its materials, energy, chemicals or other areas?
8. How high are your aspirations for environmental improvement? Compliance, prevention or front-runner?
9. Who in your organisation has responsibility for environmental improvements in product development? Are these people visible? Do they have decision-making power?

Step 4: Sketch the stakeholder-network

Classic environmental efforts in companies take their point of departure in a product or a technology, directing special attention towards the improvement of the product's life cycle performance. This approach (which is represented in Steps 1-3) is a useful way of identifying environmental focus areas for the product itself, if one assumes that the product is used in a specific way, and in a specific context.

A weakness of this approach, however, is that it is based on a large series of assumptions, as there would otherwise be too many uncertainties to allow you to make a plausible assessment of the product's environmental 'goodness'.

It is, therefore, important to identify the various stakeholders who are connected to a particular set of activities, within which the product plays a role. It is these stakeholders who experience 'value' and 'goodness' from the product. Environmental impacts often occur in the exchanges between stakeholders, e.g., in negotiations along the supply chain and/or as a result of a lack of overview of the roles and responsibilities in the product's so-called *stakeholder-network*.

A stakeholder-network consists of several types of stakeholders, for example, the manufacturing company, a component supplier, an external

designer, a freight forwarder, the authorities, customers, users, a disposal company, and so on.

To supplement our understanding of the product's environmental impacts, it is important to *sketch the stakeholder-network* of the product. Sketching the stakeholder-network gives an insight into the question which stakeholders influence certain environmental impacts. To clarify the relationship between stakeholders and the impacts that occur, one can outline *information exchanges, material flows* and the resulting *environmental impacts*.

PREPARATORY STEPS






The stakeholder-network exercise can be orga-



nised as a game. Draw a selection of stakeholders on small cards and have the participants place (and later glue) them on a large poster. Draw only the major environment-related exchanges on the poster, otherwise it becomes

confusing. Once you have discussed which stakeholders are involved in the product's life and what environmental impacts come from the various exchanges, it is time to identify five new environmental priorities from this exercise.

STEP-BY-STEP APPROACH:

<ul style="list-style-type: none"> • Identify all stakeholders appropriate for the selected product. • Draw a series of 'stakeholder cards' on paper or post-it notes. As it can often be difficult to imagine which stakeholders should be considered as candidates for the stakeholder-network exercise, it is a good idea to produce a series of pre-printed cards, from which stakeholders can be selected. • Prepare a stakeholder-network map on a large piece of paper by organising the stakeholder cards on the paper. Move the stakeholder cards around on the paper, according to their affinity to each other. 	
<ul style="list-style-type: none"> • Draw with a coloured pen the connections between stakeholders that constitute information exchange between the stakeholders. Draw arrowheads to indicate the direction of information flow. • Write on the arrows which environmentally relevant options, discussions and information that the stakeholders are exchanging. 	
<ul style="list-style-type: none"> • In the same way, draw arrows to show material flows between the stakeholders – this time with a different colour. This gives insight into how the supply chain can be optimised environmentally. The optimisation can, for example, be in the form of smart logistics, location of manufacturing facilities close to each other, the allocation of activities, etc. This also creates an overview of the direction in which the product's materials flow. 	
<ul style="list-style-type: none"> • When an overview of the stakeholders, information exchanges and material flows has been created, the task is to identify areas of the stakeholder-network, where significant environmental impacts are apparent. Environmental impacts can be drawn next to a combination of stakeholders, information exchanges and material flows, and, thereby, point towards areas in need of improvement. 	
<ul style="list-style-type: none"> • Finally, identify the five most important environmental focus areas by putting a '*' next to the relevant environmental impacts. • The exercise is complete when the group has mapped the stakeholder-network and reached a consensus regarding the prioritisation of the most important environmental focus areas. 	

Case: Identification of environmental impacts through the stakeholder-network exercise at Coloplast A/S

Coloplast places a large emphasis on the environment throughout the product life cycle. Since Coloplast's products are medical devices, environmental considerations must share first place with safety and hygiene. Furthermore, Coloplast's products are not very environmentally burdening in the actual use stage, compared to the rest of the product life cycle.

The majority of the environmental impacts of Coloplast's product arise in other parts of the life cycle, in relation to different stakeholders and due to different activities than just the use stage. Manufacturing, materials and packaging are, therefore, among the main areas of environmental concern for Coloplast.

Coloplast benefited greatly from the stakeholder-network game, gaining new insights into environmental prioritisation during the development, use and disposal of an ostomy bag.

The figure shows the various relationships sketched during the stakeholder-network exercise, also showing where the group considered environmental issues to be of importance.

Five important environmental priorities were chosen in the exercise (marked with the red "*" in the figure). These were: information exchange between the marketing and environment departments; information exchange between marketing and dealer; specification of materials from suppliers; the relationship between the product development, procurement and environment departments; and the gathering of relevant information from the customer, by the marketing department.



Example of stakeholder-network at Coloplast, where important environmental impacts have been prioritised using "*".

WHY CARRY OUT THIS EXERCISE?

The point of the stakeholder-network exercise is to create an overview of environmental problems' root causes and improvement potentials. By creating an overview of which stakeholders are connected to the product throughout its life cycle it becomes apparent which stakeholders should be considered in connection with environmental improvements – or alternatively, which stakeholders should by no means be involved in the environmental task, thus ensuring relevant and likely environmental improvements.

"The stakeholder-network exercise gave a good overview of the many stakeholders that we are dealing with. The graphical exercise was good for us to identify not only environmental impacts, but also their initiators. The exercise could not, however, have been carried out in isolation; it was a natural consequence of the previous exercises, which were necessary for us to create an overview of the product's actual environmental impacts."

[Helle Nystrup, Grundfos Management A/S]

Critical questions...

10. Which environmental requirements should/could you ask of your suppliers?
11. What do your customers expect in terms of environmental efforts or achievements?
12. Which other stakeholders can help you improve your product's environmental impacts?

Step 5: Quantify the environmental impacts

Many decisions about the product's environmental profile can be taken on the basis of experience, dialogue and scenario-building. But it is inevitable that some judgments and choices in product development must be based on hard numbers and quantitative assessments.

The fifth step in the 7-step approach is to quantify the environmental impacts using a quantitative life cycle assessment technique. The figures created in this exercise will be used to carry out an internal comparison of product alternatives and visualisation of the orders of magnitude between the impacts of the product manufacturing processes and materials, activities in the product life cycle stages and alternative life cycles.

SIMPLIFIED METHODS

Life cycle assessment tools are used to quantify the environmental impacts of products and systems. For the busy product developer, there are a number of simplified life cycle tools, such as: "Life Cycle Check" and "Ecodesignguide" from Denmark; the Austrian "Ecodesign PILOT"; the Dutch "Eco-Indicator 99" and "ECO-it"; or the Swedish "EPS".

Choice of method depends on:

- who will apply the method (a product developer, an industrial designer or an environmental specialist?)
- how much one knows about the product at the time of the use of the method, and
- whether one wishes to use a computer tool, or whether a pocket calculator would suffice, and so on.

The outcome always depends on three factors:

- *the model* one uses (for example, the processes one chooses to include in a life cycle phase, and possibly their presentation in a computer tool)
- *the data* one bases the calculations on (general or specific data, self-collected data or data from literature, older or newer data, etc.)
- *the method* itself (for example, inherent decision connected to the procedure).

Common for all methods is that one must define the product life résumé and model this within the framework of the method. Some methods include data on materials and processes which ease the quantification task, especially if the method is software-based.

FOR INTERNAL USE ONLY!

Be aware that results can vary depending on the combination and content of the three factors: model, data and methodology. And you should not take the result for more than what it is – merely a quick and general estimation.

If you wish to use quantified environmental figures in connection with external communication to customers and suppliers (for example, in environmental reporting), you must make full life cycle calculations according to ISO standards and have these reviewed by a third party. Simplified methods are not sufficient for external communication.

However, simplified methods are often both sufficient and the most useful choice for daily product development work – especially after they have been used a few times in the company, to both learn the technique and to tailor the databases and the model.

STEP-BY-STEP APPROACH:

- Choose a method for assessing the environmental impacts of your product.
- Use the results from Steps 1 through 4 to describe the product and its life cycle.
- Work step-by-step through the method and

record the different assumptions you have to make. The method typically requires data on product name, functional unit, materials, manufacturing processes, transport, use scenarios and disposal scenarios.

- The exercise is complete when the product's life cycle can be modelled in relation to its environmental impacts, and some environmental focus areas can be identified, which the method has helped reveal.
- Prepare a presentation of the results from the exercise and then identify five environmental focus areas ('*').

WHY CARRY OUT THIS EXERCISE?

The quantitative environmental exercise provides another entry point to the environmental improvement task, based on highly simplified assessment methods. The limitations of these tools are clear; many assumptions must be made and the results are only as reliable as the data and model underlying the calculations. But even with these limitations, these simplified methods give a quick overview of a product's environmental profile. In addition, you can use the tools to create scenarios where, for example, alternative processes or materials are compared.



"As part of our environment and quality management system, we have described that environmental considerations must be integrated very early into the product development process, in order to aid our decision-making when new products are developed."

[Peter Skals, Coloplast A/S]

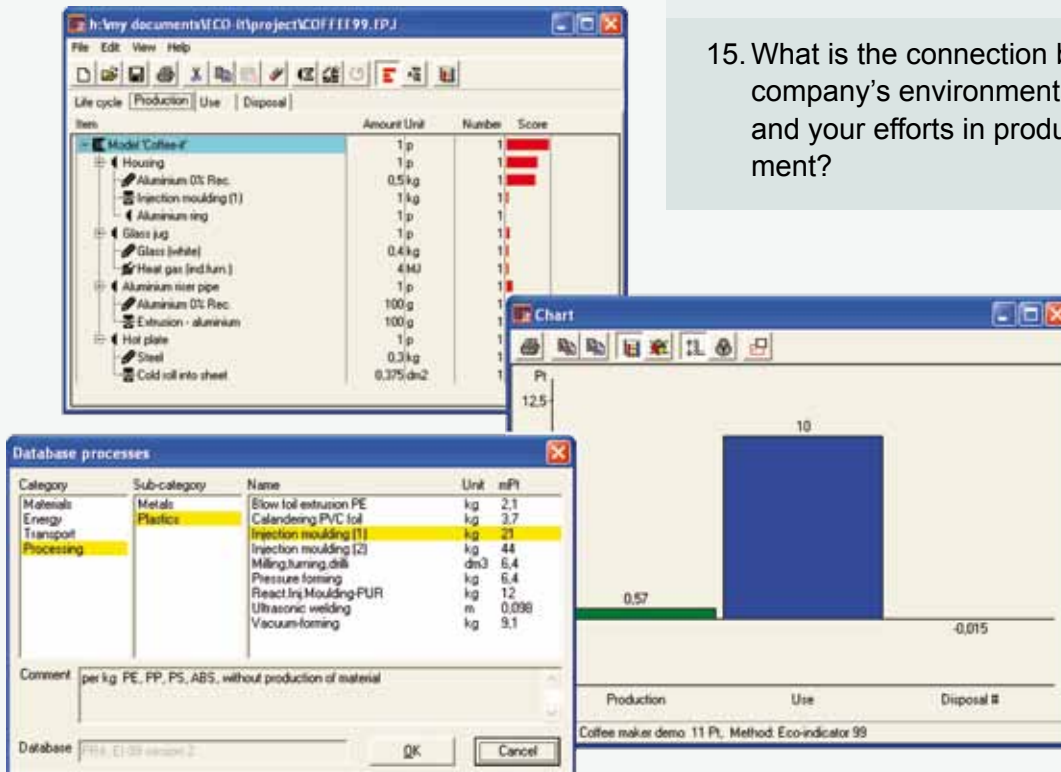
The figure shows results from the “ECO-it” tool, which, in this example, shows that the product’s environmental impact in the use stage is 20 times larger than in the manufacturing stage, and even higher than in the disposal stage.

Critical questions...

13. Which environmental impacts should be measured?

14. Which environmental considerations are included in your choice of materials and manufacturing processes?

15. What is the connection between your company’s environmental reporting and your efforts in product development?



Step 6: Create environmental concepts

A product concept is often defined as an *idea with a purpose*. And the task is no different in this step, when we talk about creating environmental concepts. The task is to create solutions for the product and the product's life cycle, which can lead to environmental improvements.

Based on the series of environmental insights that you have gained during the previous five steps, it is now time to start creating environmental concepts for the product.

There are various tools available to aid this task:

- Those, which you have always used in product development - *brainstorm*, *brainwriting*, *sketching*, etc.
- There are *checklists* and *negative checklists*, which prompt environmental thinking.

- You can create *future scenarios* (e.g., “Outline the world’s least energy-consuming house, which can be realised in the year 2020”) in order to make a leap forward and perhaps find radical environmental concepts.
- The largest help is most likely to be gained by identifying relevant *ecodesign principles* that can inspire and guide the environmental conceptualisation process.

ECODESIGN PRINCIPLES

Use the following ecodesign principles to create new product concepts, which deliver the functionality by means of new, innovative and radically improved ways. The principles apply to most products and business types.

- Reduce the **material intensity** of the product or service
By reducing the amount of material in the product, fewer material resources are required for manufacturing, the product requires less transport work, and there is less material to be landfilled or recycled. Attempt also to reduce the indirect material requirements which are related to, e.g., the extraction of raw materials.
- Reduce the **energy intensity** of the product or service
As energy supply today is not based on 100% renewable sources, and as fuels are often of fossil origin, the consumption of energy typically leads to environmental loads. These can be reduced by changing the design.
- Reduce the **dispersion of harmful substances** through the product
Substances which are harmful in themselves, but which are used to achieve certain product characteristics – e.g., brominated flame retardants – can seep from the product out into nature and into the food chain, for instance, by evaporation.
- Increase the amount of **recycled and recyclable materials** in the product
It is a good idea to improve the possibility of recycling, for example, by producing the product with few materials and by making them easily separable. At the same time, it is essential to apply increasing amounts of recycled materials in the product, since this will increase market demand for these materials.
- Optimise the product's **durability**
Unless the product has a very high environmental impact in the use stage, it is a good idea to make products that last for a long time, as this makes the production of new products for the same purpose unnecessary. At the same time, it is not useful to invest too much in the durability of products which are known to have a short use stage due to, for example, rapid technological obsolescence.

- Incorporate **environmental features** into the product
Make sure that the product is designed to reduce environmental loads, for instance, by using standby functions, low-energy features or duplex features on printers.
- **Signal the product's environmental features** through the physical design
Make the product's environmental features visible to the user, for example, by placing the standby button on the front of the product or by setting the duplex mode as default in the printer driver settings.
- Maximise the use of **sustainable resources and supply chains**
Is there a link between recyclability of the product and use of recycled materials in the production? Do we know the origins of the materials and resources we use (with respect to both environmental and ethical standards)? Have we considered alternative materials on the merits of their environmental performance?
- Optimise the product's **performance**
It is environmentally advantageous to combine several complementary functions in one product and to focus on the effectiveness of the product as a whole. The customer will evaluate the product's value, based on both its usability and its ability to efficiently meet a specific demand/desire. High perception of utility often leads to efficient use and increased durability of the product.
- **Design the life cycle first** and then the product
By thinking through all stages of the life cycle, one can achieve a very good understanding of the environmentally relevant properties the product must have, and these are then taken into account in the development process. Products which are developed on the basis of thorough knowledge of users' activities and needs have a better chance of achieving optimised life cycles and environmental profiles.

*This list of **ecodesign principles** is an elaboration on the World Business Council for Sustainable Development's checklist for environmentally sound product development.*

CREATE IDEAL CONCEPTS

An *ideal concept* is a solution proposal, which is exclusively focused on a single optimisation parameter. The aforementioned ecodesign principles can be used to create a number of ideal concepts that, for example, are optimised with regard to:

- Minimum material content in the product
- Minimum energy use throughout the product's life cycle
- Minimum content of toxic substances
- Optimal reusability
- Optimal durability
- Inbuilt environmental functions in the product
- Clarification of the environmental characteristics of the product

Use an hour on each of the above optimisation proposals (you could also add some of your own) and produce a poster for each concept, with brief explanations for specific characteristics, etc. The posters will show how far each ecodesign principle can be stretched for the current product. Good sub-solutions can then be chosen from ideal concepts, in order to construct one or more tangible and realistic environmental product concepts.

BREAK DOWN THE MENTAL BARRIERS

Despite the logical approach behind using cer-

tain ecodesign principles, one can often meet a barrier when attempting to create significant environmental improvements. The more one focuses on the need for good solutions, the harder it can be to find them. Humans seem actually to be designed in such a way that it is easier for us to imagine all the ways in which to make the product environmentally worse, and not the opposite!

A *negative brainstorm* is therefore always easy (and fun) to perform, because it is the negative aspects that we want to move away from (and the negative aspects, which disturb the process of environmental concept generation). The task is therefore to imagine *the world's most environmentally polluting product*.

STEP-BY-STEP APPROACH:

- Use 5 to 10 minutes in groups, brainstorming all the ways in which the environmental profile of your product can be made *as bad as possible!*
- Write down your ideas on post-its (one idea per post-it).
- Remember that brainstorm rules apply!
- When all negative ideas have emerged, they must be categorised in relation to the ecodesign principles.

- The next step is to turn every negative idea into one or more positive ideas. *For example, the idea “The pump is always on - no way of turning on/off” is addressing the ecodesign principle regarding energy and can be contradicted with various positive environmental ideas, such as “The pump has automatic flow regulation”.*
- The exercise is complete when all negative ideas have been created, categorised and countered with a list of positive ideas.
- Finally, identify five key environmental focus areas by putting a ‘*’ next to the relevant environmental impacts.

WHY CARRY OUT THIS EXERCISE?

You create environmental concepts in this exercise by focusing on a selected number of environmental focus areas and developing approaches that eliminate the actual problem. The many technical professions represented in the workshop group should result in a high probability of creating target-worthy solutions.

Using the environmental principles helps to create guiding stars which aid the conceptualisation process. The negative brainstorm exercise is suitable for a workshop setting, as the whole group can contribute and because there is not much time in a workshop for detailed conceptualisation.

The negative brainstorm exercise may initially seem unserious; but more often than not, the exercise helps to produce far more new and innovative ideas, than if one had systematically followed a traditional improvement strategy.

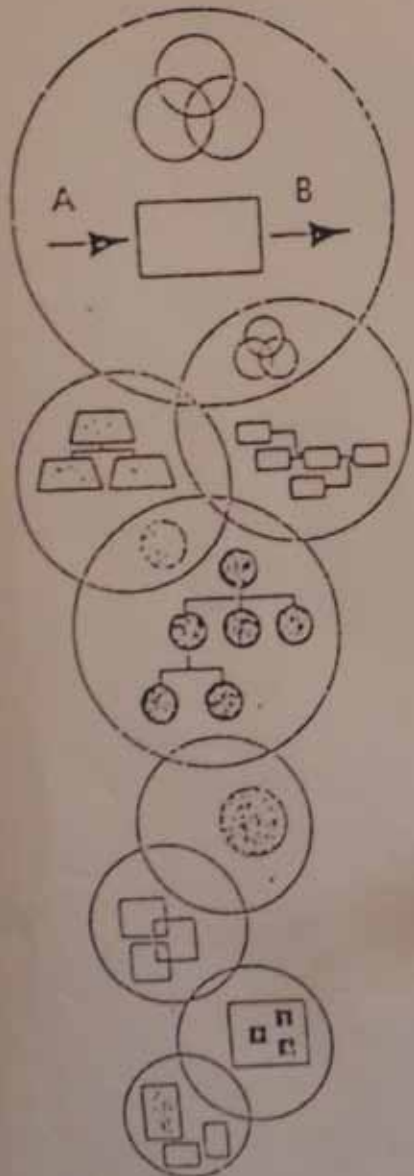
The many new ideas that were generated by the negative ones can now be prioritised and built into the product development task for further development. The creation of the ideal concepts helps to pan out the solution space for new environmental concepts.

The process that you have now completed in steps 1 through 6 has been a creative process with a sole focus on the environment. Now is the time to reflect:

- *How should the experiences from this process shape the company’s strategy and policy?*
- *How should such activities be built into the product development process in the future?*

Negativ brainstorm

Fra negative ideer til positive forslag
Valg jeres top 5 prioriteter



	Negative ideer	Po
Teknologi <i>brændstof</i>	<p>LIVER PRÆTICH FORSK STØRRE OG TUNGERE. 3.</p> <p>PRISSETTER ANBRINGTIG DUNTER MØGET HØDT.</p> <p>1 Energy storage</p> <p>Store 3 "jernkloids" med 2 huller</p>	1: 2: 3: 4:
Struktur <i>'Infrastruktur'</i>	<p>Produktion Kæde af stål Løsning Højtrykspumpe</p> <p>5</p> <p>6</p> <p>7</p> <p>8</p> <p>9</p> <p>10</p> <p>fokus på risiko - ikke at/</p>	5: 6: 7: 8: 9: 10:
Subsystemer <i>'Organer'</i>	<p>Critical questions...</p> <p>16. Which alternative available technologies can improve your product's environmental profile?</p>	
Komponenter	<p>17. What alternative products/services could meet your customers' needs with radically minimised environmental loads?</p> <p>18. How can environmental concepts be used positively in marketing?</p>	11: 12: 13:



"Earlier, the LEGO Group's principal environmental focus was on the certification of our factories. Our next step is to look increasingly at the product development process, which is relatively new for us.

A recently conducted climate exercise showed that material consumption is the most important focus area of the value chain for us, which has led to an increased focus on materials and the product development process."

[Jes Faltum, LEGO Group A/S]

Step 7: Develop an environmental strategy

For environmental efforts, ideas and requirements to become rooted in the organisation, a strategy and prioritisation of efforts is required.

The previous 6 steps in the 7-step approach have helped to develop ideas for environmental improvement by changing the product and its life cycle. If you have completed these steps carefully, you should now have a long list of environmental priorities and ideas!

The last task in this approach is to use your group's experience, inspiration and opportunities to decide on an environmental strategy. You hereby leave the reference product you have been working on, in order to attempt a generalisation of the environmental product development effort for the whole company. In the first instance, this will have to be sketched out; later on it can be refined and made specific, so that it can become a part of the company's strategic foundation and action plan.

As a result of the first 6 steps of this approach, you now have 4 x 5 sets of environmental focus areas '*'. The task is now to consolidate these 20 environmental focus areas through dialogue within the group, into a smaller, more manageable number of environmental focus areas (choose, for example, the top 10). Targets must

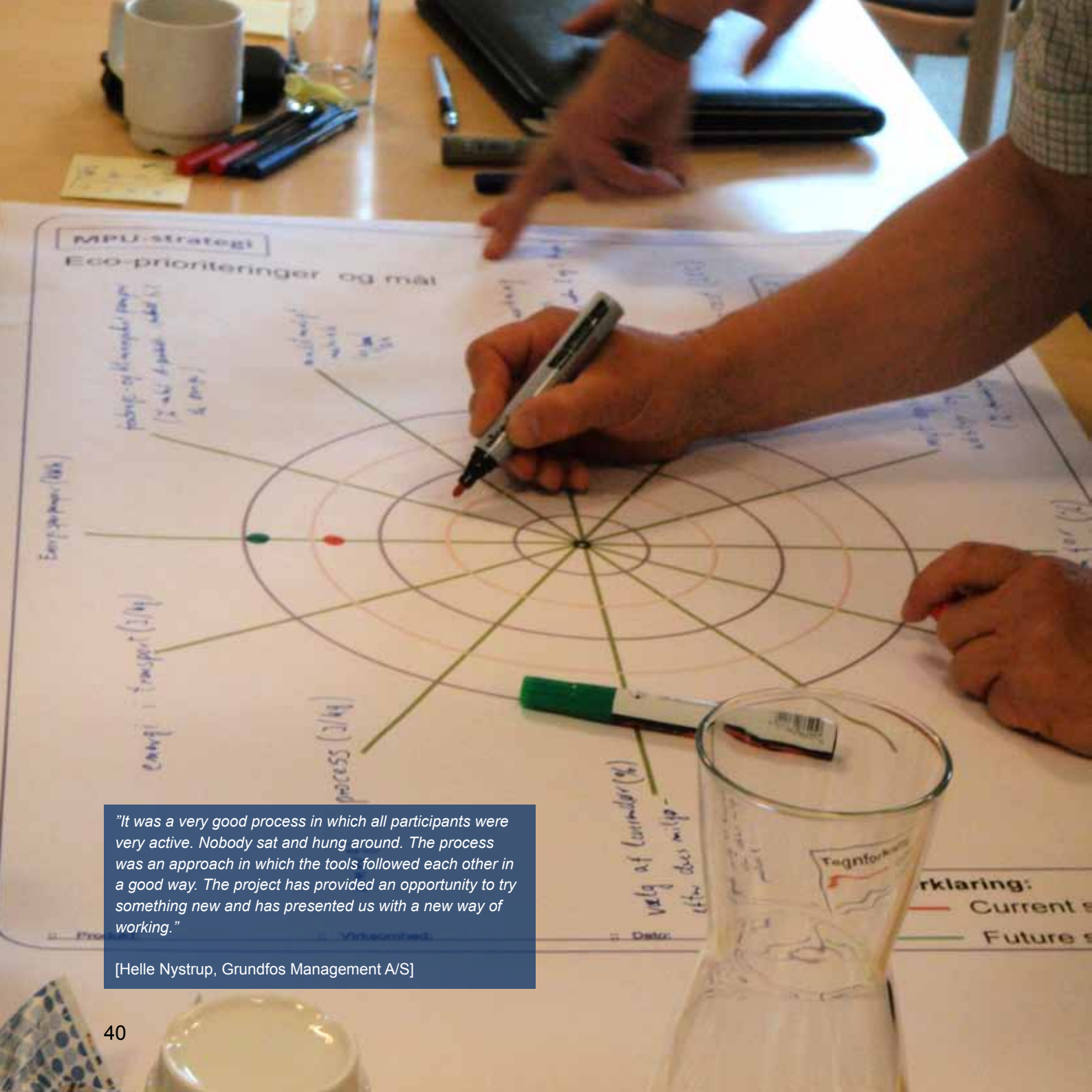
then be set for the degree of improvement expected for each environmental focus area.

STEP-BY-STEP APPROACH:

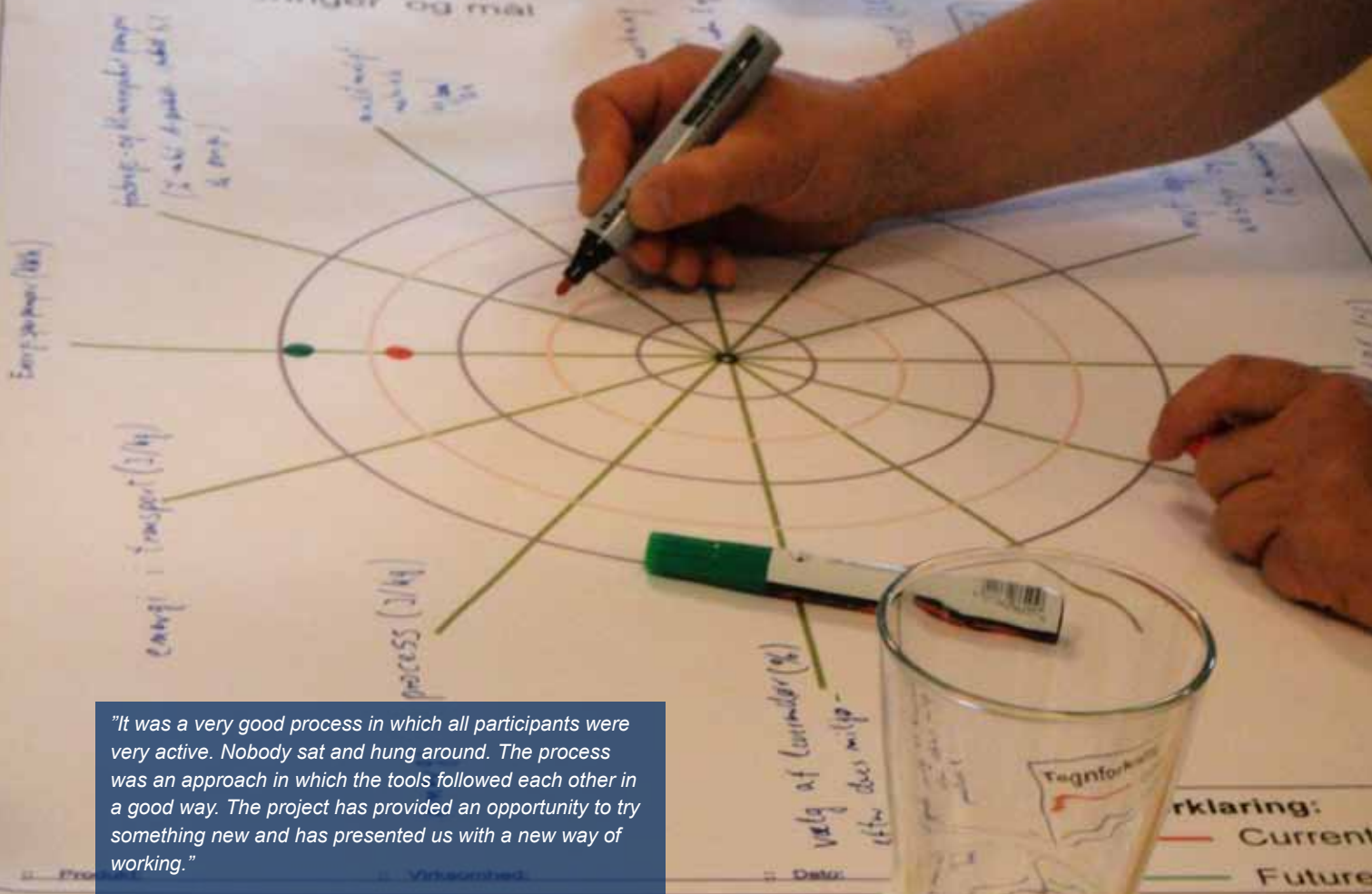
- For this task, you should draw a radar plot, on which each of your chosen 10 environmental priorities are assigned an axis.
- Choose an appropriate unit of measurement for each axis of the radar plot (e.g., kg, %, mg, J, km, number of years, or mPt).
- Then, use two colours to represent *current status* and *future goals*.
- Assign responsibilities within the organisation, i.e., appoint people who can take on the coordination of the task of creating the environmental improvements within each focus area.

When this exercise is carried out in a workshop setting it is often the case that, even if appropriate units have been selected for each environmental priority, it is not possible to commit to absolute and quantified improvements for each focus area. Therefore, one can instead begin by operating with stepwise goals (e.g., a scale of 0 to 4) or relative improvements (e.g., factor 2, 3, 4 or "50% reduction"). These units can be adjusted later.

Even though the goals set in the workshop will most probably not become the exact same final



MPU-strategi
Eco-prioriteringer og mål



"It was a very good process in which all participants were very active. Nobody sat and hung around. The process was an approach in which the tools followed each other in a good way. The project has provided an opportunity to try something new and has presented us with a new way of working."

[Helle Nystrup, Grundfos Management A/S]

goals for the company, it is important to immediately discuss and, if possible, select strategies to conduct the process.

Should the objectives be achieved through repeated consideration in future workshops, through integration in the product development process or through being made visible in the environmental accounts? Strategic approaches should be linked to the individual goals at the workshop.

When the strategy proposals are in place, it is important to define the implementation task, so that the coordinators of each focus area can put

deadlines on their activities and begin to make individual action plans for their tasks.

The task *after* this step is to work through the results of step 7, putting real numbers onto the units of each axis of the radar plot and then to develop a comprehensive environmental action plan.

The environmental coordinator's role in the company is to:

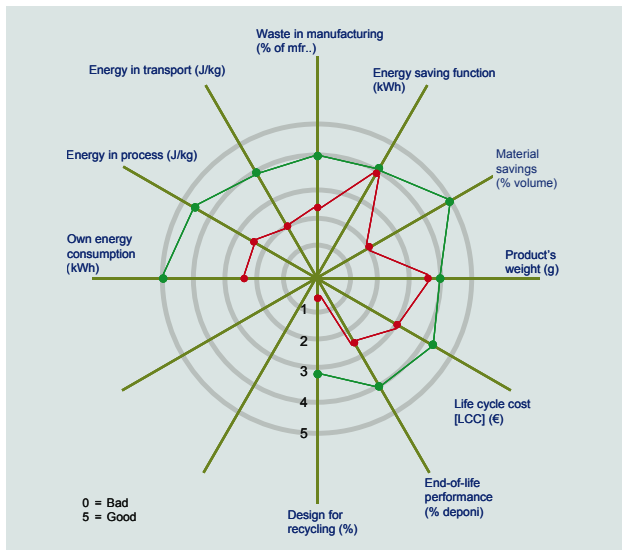
- adapt the company's environmental targets for the company's general goals
- create an environmental strategy, in order to achieve the defined goals, and
- follow up on the environmental strategy and implement it through specific action plans.

Critical questions...

19. What are the 10 key environmental focus areas for your business?

20. Which environmental principles or activities in product development can contribute to improvements in each identified focus area?

21. Which parameters will you use to measure the environmental performance of product development?



Ensuring implementation in the company

An environmental improvement process such as this can feel safe, inspiring and creative when you are sitting together in the workshop room. It is a challenging process after the workshop to ensure that the ideas, priorities and tools find a place in the company.

As indicated in Step 7, the environmental considerations should be aligned to the company's overall development. Objectives, strategies and action plans should, therefore, be coordinated with other initiatives.

The selection of one or more dedicated coordinators is the first step in this process. In relation to the company management, the coordinator has the major task of communicating and mediating the environmental effort with the company's other objectives and strategies. Generally, the coordinator has an intermediary role towards the rest of the company, which is very important if the strategy is to be realised.

If the resources can be devoted to the positive and systematic environmental improvement in the company, it is certain that the investment will pay off in several areas:

- Meeting the company's social obligations
- Prevention in relation to future environmental concerns and requirements
- Demonstrating the company's environmental stance
- Improved view of and influence over the product life cycle
- A service-oriented view of the product
- Robust and innovative product concepts.

It is also important that efforts for environmental improvements spread from product development and out to all relevant parts of the company.

Self-diagnosis

Once you have completed the 7-step approach, attempt to answer the following questions. If you can answer all of them, you are ready to make environmental improvements!

1. Where in the product's life cycle do you see environmental impacts?
2. What is it in the use of the product that creates environmental impacts?
3. Can the product's environmental profile be justified when compared to the actual value it provides to the user?
4. Where in the product's life can you see environmental impacts?
5. What functions are related to the product's environmental impacts?
6. Does the customer know what environmental problems s/he is buying?
7. Are your product's main environmental impacts to be found in its materials, energy, chemicals or other areas?
8. How high are your aspirations for environmental improvement? Compliance, prevention or front-runner?
9. Who in your organisation has responsibility for environmental improvements in product development? Are these people visible? Do they have decision-making powers?
10. Which environmental requirements should/could you ask of your suppliers?
11. What do your customers expect in terms of environmental efforts or achievements?
12. Which other stakeholders can help you improve your product's environmental impacts?
13. Which environmental impacts should be measured?
14. Which environmental considerations are included in your choice of materials and manufacturing processes?
15. What is the connection between your company's environmental reporting and your efforts in product development?
16. Which alternative available technologies can improve your product's environmental profile?
17. What alternative products/services could meet your customers' needs with radically minimised environmental loads?
18. How can environmental concepts be used positively in marketing?
19. What are the 10 key environmental focus areas for your business?
20. Which environmental principles or activities in product development can contribute to improvements in each identified focus area?
21. Which parameters will you use to measure the environmental performance of product development?

Useful literature

Simplified methods (electronic):

Ecodesignguide.dk (homepage); Willum, O. et al.; IPU, Dansk Toksikologisk Center, 2005

Ecodesign PILOT, www.ecodesign.at/pilot (homepage)

Wimmer, W.; Vienna University of Technology, Austria, since 1999

ECO-it ecodesign software; www.pre.nl/eco-it (homepage)
PRé Consultants, Amersfoort, Holland, 1996-2008

Oil Point Method; www.designinsite.dk, Bey/Lenau; IPL, DTU, since 2000

Simplified methods (text-based):

Produkt-Livscykluscheck; Wenzel, H.; Caspersen, N.; Schmidt, A.; IPU, dk-TEKNIK, Miljøstyrelsen, 2002

Miljørigtig konstruktion; Olesen, J.; Wenzel, H.; Hein, L.; Andreasen, M.M.; IPU, Miljøstyrelsen, DI, 1996

Miljøhensyn i produktudvikling; Olesen, J.; Hauschild, M.; IPU, 1998

Miljøstyrelsen, MiljøNyt nr. 65, 2002, **Kom godt i gang med livscyklustankegangen**; Remmen, A. & Münster, M.

General methods:

The Eco-indicator 99 – A damage-oriented method for Life Cycle Impact Assessment;

Goedkoop, M.; Spriemsma, R.; PRé Consultants, Amersfoort, Holland, 1999

Miljöanpassad produktutveckling; Ryding, S.-O. et al.; Industriförbundet, Stockholm, Sverige, 1995

Environmental Assessment of Products;

Wenzel, H.; Hauschild, M.; Alting, L.; IPU, Danish EPA, DI, 1996

Eco-Efficiency: Creating more value with less impact;

World Business Council for Sustainable Development, Zurich, Switzerland, 2000

Ecodesign Navigator; Simon, M.; Evans, S., McAloone, T.C.; Sweatman, A.; Bhamra T.; Poole, S; Manchester Metropolitan University & Cranfield University, UK, 1998

See also:

Danish Environmental Protection Agency:

www.mst.dk

Confederation of Danish Industry: www.di.dk

DTU Management Engineering:

www.man.dtu.dk

IPU Product Development: www.ipu.dk

This Guide provides inspiration and suggests a stepwise approach to integrating positive environmental effects into the company's design and product development, so as to clarify your company's opportunities to create synergy between environment and business creation.

The Guide is aimed at product developers with the task of building environmental thinking into the development process and, thereby, also into products.

It has been created on the basis of a review of environmentally-oriented methods and product development activities in Danish and international companies, as well as on a series of workshops with Danish companies.

If the resources can be devoted to the positive and systematic environmental improvement in the company, it is certain that the investment will pay off in several areas:

- Meeting the company's social obligations
- Prevention in relation to future environmental concerns and requirements
- Demonstrating the company's environmental stance
- Improved view of and influence over the product life cycle
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- Robust and innovative product concepts.