Design and Decision Making: Backcasting from principles to implement cradle-to-cradle

Augusto Cuginotti, Karen Marie Miller, Freek van der Pluijm

School of Engineering

Blekinge Institute of Technology

Karlskrona, Sweden

2008

Thesis submitted for completion of Master of Strategic Leadership towards Sustainability, Blekinge Institute of Technology, Karlskrona, Sweden.

Acknowledgements

"Click and write acknowledgements here"

Executive Summary

This thesis explores the synthesis of the cradle-to-cradle concept and a framework for strategic sustainable development to support organizations in a transition towards long-term prosperity. The research focus is the planning and design of human systems for sustainable interactions between human society and the biosphere. Within this context, a strategic planning process is explored and developed specifically for the Dutch context with the intent of working towards creating sustainable interactions and relationships with the larger system. This process is tested within the Province of Limburg, a provincial government in the south of the Netherlands. The approach is outlined by first introducing the physical systems relevant to the study: cyclical living systems and the linear industrial system. Then, the link between people's mental models and methods of designing relationships that influence how human society interacts with the biosphere is explored. In this context, two different mental paradigms are explained, linear and cyclical thinking. Finally, the context of the case-study is introduced, and the approach is developed to support the transition from a linear to a cyclical society by the provision of a strategic planning tool that helps individuals and organizations to think and plan in a more systemic way. Conclusions suggest that cradle-to-cradle and the framework for strategic sustainable development are highly complementary approaches to strategic sustainable development, and that used together they provide a solid basis for a strategic transition towards the creation of a sustainable society.

Glossary

cradle-to-cradle (C2C): Throughout the thesis, this term refers to the concept of cyclical design of human systems. It is seperate from any specific strategy to arrive at that goal.

Sustainability: the capacity to create, test and maintain adaptive capacity (Holling, 2004)

Development: the process of creating, testing and maintaining opportunity (Holling, 2004)

Sustainable Development: refers to the goal of fostering adaptive capabilities while simultaneously creating opportunities (Holling, 2004)

Framework for Strategic Sustainable Development (FSSD): A framework

5 level framework: A generic 5 level framework (system, success, strategy, actions and tools) for planning in complex systems

Sustainability Principles: Consensus-based scientific principles providing a complete and systematic conditions for sustainability (Robert, 2000)

Eco-effectiveness: the concept of eco-effectiveness proposes the transformation of products and their associated material flows such that they form a supportive relationship with ecological systems and future economic growth. (Braungart et al. 2007)

Eco-efficiency:

Biological metabolism:

Technical metabolism:

Upcycling:

Teleology: the explanation of phenomena by the purpose they serve rather than by postulated causes.

Table of Contents

List of Figure and Tables

"Click and insert list of figures and tables here"

1 Introduction

1.1 Sustainable Development and the nested system model

Sustainable Development is a concept based upon the creation of human societies and human systems that can survive within the biosphere over the long term. A widely accepted definition was introduced in the Brundtland Commission's report as: 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). This definition, though often quoted, is difficult for decision-makers to interpret into concrete strategies and actions.

More recent work has stressed the importance of highlighting the process nature of sustainable development (Bagheri and Hjorth 2007, Holling 2004) and the following definition has been proposed: 'Sustainable development refers to the goal of fostering adaptive capacities while simultaneously creating opportunities' (Holling 2004, Bagheri and Hjorth 2007). Both definitions are value statements of intent for the design and development of human systems, although the latter places more emphasis on efforts towards process and structural change to allow for continual evolution (Ring 1997). The specific systems under study when it comes to sustainable development are introduced with the following nested system model:

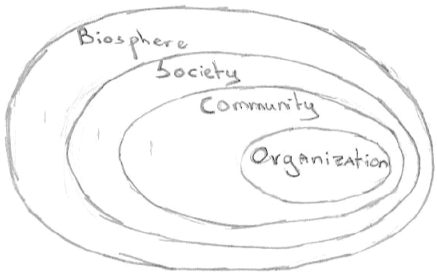


Fig. 1: Nested system model - Individual within community within society within the biosphere. All system levels are interconnected and interaction between the scales is such that change (or evolution

or transformation or reorganization) at one scale affects change at other scales (Holling 2004).

The process of sustainable development is an ideal of development efforts (Mitroff and Linstone 1993) in this series of nested complex systems. Due to the complexity of the systems under consideration, and the evolution of social values over time, it is most useful to frame sustainable development as an ongoing process that evolves alongside our understanding of the socio-ecological systems (Bagheri and Hjorth 2007). Our understanding of the system is evolving, and it has become apparent that the development of human society is on an unsustainable course. The next section explores the history of this relationship between human society and the biosphere, and proposes an alternative worldview from which to define and plan in a way that supports long-term prosperity.

1.2 Linear thinking, cyclical thinking: human society within the biosphere

The biosphere works in cycles of birth and re-birth, cycling nutrients, water and materials in ever self-sustaining physical flows based on regenerating cycles. For most of human history people fit within these cycles and found a balance with the natural world. Living in this matter, humans thrived in times of abundance and dwindled in times of scarcity. Ten thousand years ago, when totalitarian agriculture was invented and started to spread, the majority of the human population chose the course that is often referred to as being civilized (Quinn 1992).

From that moment on, modern humans did not anymore experience themselves as a part of nature but as an outside force destined to dominate and conquer it. People spoke of a battle with nature, forgetting that, if the battle was won, humans would be on the losing side (Schumacher 1973). In the sixteenth and seventeenth centuries the medieval worldview, based on Aristotelian philosophy and Christian theology, changed radically. The notion of an organic, living, and spiritual universe was replaced by that of the world as a machine, and the world-machine became the dominant metaphor of the modern era. This radical change was brought about by the new discoveries in physics, astronomy, and mathematics known as the Scientific Revolution and associated with the names of Copernicus, Galileo, Descartes, Bacon, and Newton (Capra 1996). Equipped with the technological applications of Newtonian science, modern capitalism led to

an unparalleled growth in economic productivity. Its values were materialistically oriented: the good is a large production per capita, and the better a still larger production (Laszlo 1996). The illusion of unlimited powers, nourished by astonishing scientific and technological achievements, has produced the concurrent illusion of having solved the problem of production. The latter illusion is based on the failure to distinguish between income and capital where this distinction matters most (Schumacher 1973). An attitude to life which seeks fulfilment in the single-minded pursuit of wealth – in short, materialism – does not fit into this world, because it contains within itself no limiting principle, while the environment in which it is placed is strictly limited (Schumacher 1973).

This linear way of interacting with nature is having cumulative and far reaching effects on the health of the biosphere. Not only are the effects of this accumulation of waste and degradation of natural systems accelerating, but also the potential for redesign of the systems is being undermined (Robèrt et al. 2004, 32). The seemingly unrelated effects are interconnected and stemming from the same underlying causes. Thus, addressing the root cause of the problems provides an opportunity to redesign issues out of the system at the source. The basic tension is one between the parts and the whole. In twentieth-century science the holistic perspective has become known as 'systemic' and the way of thinking it implies as 'systems thinking' (Capra 1996). The more we study the major problems of our time, the more we come to realize that they cannot be understood in isolation. They are systematic problems which are harming the biosphere and human life in alarming ways that may soon become irreversible (Capra 1996). Ultimately, these problems must be seen as just different facets of one single crisis, which is largely a crisis of perception. It derives from the fact that most of us, and especially our large social institutions, subscribe to the concepts of an outdated worldview, a perception of reality inadequate for dealing with our overpopulated, globally interconnected world (Capra 1996). In the shift from mechanistic thinking to systems thinking, the relationship between the parts and the whole has been reversed. The properties of the parts are not intrinsic properties, but can be understood only within the context of the larger whole. Thus systems thinking is 'contextual' thinking; and since explaining things in terms of their context means explaining them in terms of their environment, we can also say that all systems thinking is environmental thinking (Capra 1996).

We must thoroughly understand the problem and begin to see the possibility of evolving a new life-style, with new methods of production and new patterns of consumption (Schumacher 1973). The new concepts in physics have brought about a profound change in our worldview; from the mechanistic worldview of Descartes and Newton to a holistic, ecological view (Capra 1996). The new paradigm may be called a holistic worldview, seeing the world as an integrated whole rather than a dissociated collection of parts. It may also be called an ecological view, if the term 'ecological' is used in a much broader and deeper sense than usual. Deep ecological awareness recognizes the fundamental interdependence of all phenomena and the fact that, as individuals and societies, we are all embedded in (and ultimately dependent on) the cyclical processes of nature (Capra 1996). A new and healthy relationship between society and the biological world will require a fundamental change in the way the physical flows associated with the human economy interact with the larger biological systems (Senge et al. 2001).

From the systemic point of view, the only viable solutions are those that are 'sustainable' (Capra 1996). Various models and concepts for sustainable development address this issue of cyclical design and interaction in a systematic way. The next sections will elaborate on how two approaches: cradle-to-cradle design and a Framework for Strategic Sustainable Development can be complementary within this context to support a transition towards a cyclical way of interacting with the biosphere. This, in a nutshell, is the great challenge of our time: to create sustainable communities; social and cultural environments in which we can satisfy our needs and aspirations without diminishing the chances of future generations (Capra 1996).

1.2.1 Cradle-to-cradle and FSSD

Both cradle-to-cradle and the framework for strategic sustainable development (FSSD) are methodologies for planning and/or designing developed with a whole-systems vision of sustainability. Both have at their core an understanding of the cyclical nature of the biosphere, and the inherent goal of supporting human society in making a transition from the current linear system to a cyclical one that can be sustained over the long-

term within the biosphere. This thesis will explore key components of both approaches, working towards the following purpose and research questions.

1.3 Purpose of the Study and Research Questions

The goal of this study is to provide a process tool that assists organizations to plan strategically and collaboratively towards sustainable development, integrating the strengths of both the cradle-to-cradle concept and FSSD. In order to approach this goal, this thesis tests the following hypothesis:

Backcasting from principles is a systematic and elegant way to strategically implement cradle-to-cradle.

The purpose, hypothesis and the context of the study have led to the following research questions:

Main Research Question

How can an organization successfully strategically transition towards sustainability using the cradle-to-cradle concept?

Sub Research Questions

How can the cradle-to-cradle concept be framed in a way that supports sustainable development?

How can sustainable development, based on the cradle-to-cradle metaphor, optimally be implemented?

1.4 Scope and Limitations

The recommendations provided are as generic as possible, given the methodology of testing within a specific case study. However, it should be noted that the context of the case study in the Netherlands is unique, and

could limit the generality of the results. The main focus of this study is on the strategic level.

2 Methodology

2.1 Chosen Approach

The focus of this research was defined through conversations with decision makers of various levels of society in the Netherlands. An action research approach was taken, with the goal of creating a study to support the transition towards a sustainable society within the Netherlands. Specifically, cradle-to-cradle has been embraced as a development strategy at many levels of Dutch society, and therefore, the development of the theoretical framework incorporated the strengths of the cradle-to-cradle concept with the intent of framing cradle-to-cradle in a way that supports sustainable development at the societal scale.

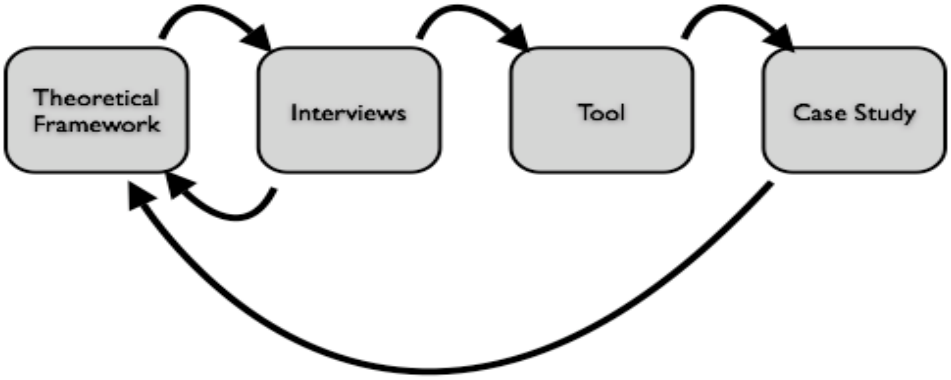


Fig 2: iterative research approach: First, a theoretical framework was created based on literature reviews and exploratory interviews. Then, the theoretical framework was tested through interviews with experts. Finally, a process tool was created and tested within the context of a specific case study with a provincial government.

2.2 Research Phases

2.2.1 Exploratory Interviews

Interviews were conducted with practitioners at all levels of society involved in the cradle-to-cradle networks in the Netherlands (for full list of interviewees see Appendix A). Questions were related to the implementation of cradle-to-cradle in practice. Interviews took place over the course of a week, and informed the development of the research questions as well as the methodological approach. Analysis was performed directly following the interviews, with the impressions, experiences and ideas encountered during these interviews analyzed through the lens of the theoretical framework presented below.

2.2.2 Theoretical Framework Development

The 5 Level Framework for Planning in Complex Systems

The theoretical framework is based on the following generic 5-level model for planning in complex systems, where five hierarchically different system-levels are delineated. The distinction between the levels is maintained while planning and structuring information, while the interrelatedness between the levels is acknowledged and can then be utilized in a deliberate and methodical fashion. The five levels are:

1. **System:** Principles for the *constitution* of the system (e.g. ecological and social principles).
2. **Success:** Principles for a favourable *outcome* of planning within the system (e.g. *principles for sustainability*).
3. **Strategy:** Principles for the *process* to reach this outcome (e.g. *principles for sustainable development*).
4. **Actions:** *i.e. concrete measures* that comply with the principles for the process to reach a favourable outcome in the system (e.g. recycling and switching to renewable energy).

5. **Tools:** to monitor and audit (i) the relevance of actions with reference to principles for the process (e.g. indicators of flows and key-figures to comply with principles for sustainability), and/or monitoring (ii) the status of the system itself, and impacts (e.g. ecotoxicity and employment), or reduced impacts, as a consequence of strategically planned societal actions. (Robèrt et al. 2004, 28-50)

The analysis of the system was based on literature review on both FSSD and cradle-to-cradle. The focus of the research was on connecting and comparing the two concepts. The methodology is based upon a similar analysis of the Industrial Ecology (IE) concept performed by Korhonen in 2004, in which the five-level model was used to structure information. As a first step in structuring the cradle-to-cradle concept, an analysis of the concept was performed at each of the five system levels (system, success, strategy, actions, tools).

Principles for success from both FSSD and the cradle-to-cradle concept were analysed in through the lens of how they can be used to support the strategic planning process towards sustainability.

The current implementation strategies of cradle-to-cradle projects were critically analysed through the lens of the framework for strategic sustainable development. The implied and stated cradle-to-cradle strategic guidelines were scrutinized for strengths and weaknesses.

2.2.3 Interviews

Interviews were conducted; both with an expert panel of practitioners within the cradle-to-cradle network in the Netherlands, and with international cradle-to-cradle and sustainable development, and process development experts. These interviews provided input and feedback to develop, test and refine both the theoretical framework and the strategic planning process.

2.2.4 Development of a Strategic Planning tool/ process

This phase served to explore a strategic process to develop guidelines using the cradle-to-cradle language for an organization in order to develop their strategy in conjunction with the principles of cradle-to-cradle, while working towards sustainable development.

Based on input from previous phases, a generic strategic planning tool/process was developed. The objective of the tool was to create, based on known scientific processes, the most suitable process to engage organizations in a strategic social learning process towards sustainable development.

This analysis formed the basis for the design, and testing of a strategic planning process for use in the Dutch context. The design and application of the process was grounded in an assessment of the current reality, based on interviews with a diverse group of leaders from within Dutch society.

2.2.5 Case Study

Dutch Society

Decision-makers from various backgrounds and levels of Dutch society were interviewed to provide an understanding of the current reality of the application of the cradle-to-cradle concept in the context of sustainable development.

Brainstorming sessions were held, both with the research group, and representatives from Enviu, a sustainability incubator based in Rotterdam, in order to explore and identify concepts to aid in a societal transition towards sustainability based on the cradle-to-cradle concept.

Province of Limburg

The strategic planning process was prototyped and tested through a workshop with representatives from various departments at the Province of

Limburg, a provincial government in the south of the Netherlands. The process was applied to the internal sustainability efforts at the province.

Representatives Interviews

- Paul Levels, Province of Limburg
- Dick Thesingh, Marketing Manager Chamber of Commerce Province of Limburg
- Frederieke Vriends, Sustainable Development project leader Province of Limburg
- Joey Clark, Sustainable Development project leader, Province of Limburg

Debrief and feedback

A feedback form was filled out by workshop participants at the end of the session and a debrief session was held the day following the workshop to receive feedback on possible improvements in both process and content.

3 Results

3.1 Concepts

3.1.1 The Framework for Strategic Sustainable Development

The roots of FSSD

The FSSD was developed through a process of scientific consensus at the principle level that has taken place in a learning dialogue between scientists and policy makers in business and politics (Broman et al. 2000). This process began in the mid 80s, and it continues to evolve (Broman et al. 2000). The framework is designed to provide strategic direction, or a 'compass', for organizations' sustainability initiatives by providing a generic framework within which to structure information in a way that supports decision making (Broman et al. 2000). Such a framework, based on first order principles, allows decision makers to interpret details and understand strategies without losing sight of the bigger picture (Broman et al. 2000). This allows for improved effectiveness and strategic planning of actions in contributing to the process of sustainable development.

Within the generic 5 level model presented in section 2.1, the FSSD approach to Sustainable Development defines the system based on the nested system model introduced in section 1.1. Specific principles for success and strategic guidelines form essential components of the FSSD, and are as follows:

Success

Based on study of the dynamic interrelationships between society and the biosphere, and an understanding of science; including thermodynamics and conservation laws, biogeochemical cycles, basic ecology, the primary production of photosynthesis (Robèrt et al 2004); Robèrt et al. have, based on scientific consensus, identified the following three sustainability principles:

In a sustainable society, nature is not subject to systematically increasing…

I …concentrations of substances extracted from the Earth's crust,

II …concentrations of substances produced by society,

III …degradation by physical means

Social sustainability is addressed by the fourth sustainability principle:

In a sustainable society…

IV…people are not subject to conditions that systematically undermine their capacity to meet their needs.

These sustainability principles have been specifically designed to support the strategic process of backcasting from principles, which is the heart of the FSSD strategy.

Strategy: Backcasting and strategic guidelines

Planning in complex systems is supported and guided by applying the concept of backcasting. Backcasting, as opposed to forecasting methods of predicting the future, is about working backwards: setting the desired future state and working to define which steps are needed to attain it. The main difference between the two is that the first focuses on designing how desirable futures can be attained and the latter works on figuring out futures that are likely to happen (Robinson 1990).

In the field of sustainability it is not particularly helpful to know scenarios of the future that are most likely to happen. Current sustainability problems are based on the current trends and ways of thinking in society. Therefore, in order to strategically plan for the transformational change required to create a sustainable society, it is vital to plan normatively rather than perpetuating current trends. Given multiple possible futures, decision makers are looking for the most desirable rather than the most likely one (Robinson 1988).

FSSD specifically focuses on the process of backcasting from sustainability principles rather than scenarios. While backcasting, the process of choosing a scenario of what would be the most desirable future can be a hard task for such a complex theme. To create a detailed picture of the

future in those circumstances would be like attempting to solve a difficult puzzle in a room with five hundred people and limited time.

Instead of focusing on the creation of a desired scenario, FSSD provides a set of principles to work as boundary conditions. As long as these principles are complied with, the scenario developed within these boundaries is inherently sustainable. Backcasting from basic principles explicitly expresses the constraints of the system, and allows for creativity on the course of the development of strategy, actions, visions and goals while providing general rules to guide decisions in the right direction rather than providing a solidified or prescriptive vision of the future (Holmberg and Robèrt 2000).

Actions and Tools

Any tools and actions that support strategies towards sustainable development are encouraged while applying the FSSD. When various tools and concepts are used within this model, their complimentary nature is highlighted, and it is easier to determine ways to use them in parallel, each for its specific purpose (Robèrt 2000). Levels in the five level model are interdependent, and diverse tools and actions are required at every level, selected according to context (Robèrt 2000).

3.1.2 Cradle-to-cradle

The roots of cradle-to-cradle

In a 1998 speech, William McDonough, architect and co-author of the book Cradle to Cradle, describes the three defining characteristics that we can learn from natural design as follows:

1. Everything we have to work with is already here.
    - Everything is cycled constantly with all waste equalling food for other living systems.
2. Energy comes from outside the system in the form of perpetual solar income.
    - It is an extraordinary complex and efficient system for creating and cycling nutrients, so economical that modern

methods of manufacturing pale in comparison to the elegance of natural systems of production.

3. Biodiversity is the characteristic that sustains this complex and efficient system of metabolism and creation.
    - What prevents living systems from running down and veering into chaos is miraculously intricate and symbiotic relationship between millions of organisms, no two of which are alike (McDonough 1998).

Based on this understanding, and on the understanding that society is inherently part of nature, of the biosphere, we can design our systems for producing and living in accordance to this way of design. From an industrial design perspective this means developing materials, products, supply chains, and manufacturing processes that replace industry's cradle-to-grave manufacturing model (McDonough and Braungart 2002b).

The cradle-to-cradle approach specifically focuses on the concept of biological and technical metabolisms as a method to close material loops. In the biological metabolism, the nutrients that support life on Earth - water, oxygen, nitrogen, carbon dioxide - flow perpetually through regenerative cycles of growth, decay and rebirth in such a way that waste equals food (McDonough and Braungart 2002a). The concept of cradle-to-cradle suggests that the technical metabolism can be designed to mirror natural nutrient cycles; as a closed-loop system in which valuable, high-tech synthetics and mineral resources circulate in an endless cycle of production, recovery and remanufacture (McDonough and Braungart 2002a).

Preliminary research and exploratory interviews have identified that the current approach used by individual organizations working towards the cradle-to-cradle vision is not necessarily compatible with the sustainability of the larger system in mind. In order to coordinate strategy to shift to sustainability at a societal level, material transitions and energy transitions to renewable energy sources need to be linked. In particular, the current focus on material replacement is often more energy intensive than traditional production methods, leading to a trade-off in terms of absolute physical impact of activities, depending on the energy source used (quote needed – Korevaar, 2008?).

In order to achieve a sustainable relationship with the ecological systems that society is interacting, a societal infrastructure needs to be in place that

enables the stream of materials either into a biological metabolism or into a technical metabolism. The effective management of nutrient flows associated with the biological and technical metabolism necessitates the formation of collaborative business structures with the role of coordinating the flow of materials and information throughout the product life cycle (Braungart et al. 2007).

Manufacturers require information from suppliers concerning the exact composition of their intermediate products and disassembly capabilities at recovery sites; customers need information on how to deal with the product after its use period; recyclers need information on appropriate dismantling processes and material composition.

This brings questions as to how to apply this concept in practice since the current economic system is set up in such a way that it is not necessarily economically viable to re-capture that waste and there is limited incentive to develop that infrastructure.

Individual businesses generally have control only over a small portion of the material flow systems of which their products is a part, and are incapable of directing the flow of materials or exchanging intelligence with other actors throughout the product's life cycle. Manufacturers may be able to positively define the materials in their products as biological or technical nutrients, but once the product has been passed on to customers they have little control over the fate of its constituent materials. (Braungart et al. 2007)

The optimal way of encouraging the design of a societal infrastructure based on the cradle-to-cradle metabolisms is a discussion that is only just about to start. At the same time, strategies need to be developed that support the transition towards this infrastructure and tools need to be developed that support entrepreneurs and community builders in their efforts of making their contribution in the transition towards a cradle-to-cradle infrastructure.

Processes will need to be developed to complete the links for a circular supply chain. These new mechanisms will need to be designed to fit the needs of individual organizations, but collaboration and systems thinking will be key to ensuring that they also move in the direction of societal sustainability.

Eco-effectiveness

In the words of McDonough and Braungart, cradle-to-cradle distinguishes itself from sustainability in the way it approaches efficiency; "It is about doing good instead of being less bad." Cradle-to-cradle strives for eco-effectiveness instead of eco-efficiency.

Eco-efficiency strategies focus on maintaining or increasing the value of economic output while simultaneously decreasing the impact of economic activity upon ecological systems (Verfaillie and Bidwell 2000). Whereas the concept of *eco-effectiveness* proposes the transformation of products and their associated material flows such that they form a supportive relationship with ecological systems and future economic growth (Braungart et al. 2007). With eco-effectiveness, the goal is not to minimize the cradle-to-grave flow of materials. Instead, by the creation of cyclical, cradle-to-cradle, metabolisms, materials will be able to that maintain their quality as resources and be used for high level purposes through either re-use or upcycling. The authors suggest that this inherently generates a synergistic relationship between ecological and economic systems – leading to a positive recoupling of the relationship between economy and ecology (Braungart et al. 2007).

The focus on eco-effectiveness emphasizes strategies such as cradle-to-cradle design and intelligent materials pooling, which deal directly with the question of maintaining or upgrading the quality and productivity of material resources. Eco-effectiveness does not call for minimization of material use or prolonged product lifespan. In fact, it celebrates the creative and extravagant application of materials and allows for short product lifespans under the condition that all materials retain their status as productive resources. Even the application of toxic materials is acceptable as long as it takes place in the context of a closed system of material flows and the quality of the material is maintained (Braungart et al. 2007). McDonough and Braungart nonetheless do acknowledge that efficiency and effectiveness can be complementary strategies (Braungart et al. 2007).

3.1.3 Cradle-to-Cradle x FSSD analysis

It is proposed that the applications of the concept of cradle-to-cradle can contribute to all five levels in the five-level model. Specifically, it is a

concept with great potential to stimulate creativity in the design of a sustainable society. The SSD Framework, on the other hand, provides a systems and science based structured framework for decision-making and prioritization of specific actions. It is suggested that cradle-to-cradle and FSSD are highly complementary approaches to strategic sustainable development, and that used together they provide a solid basis for a strategic transition towards the creation of a sustainable society.

The following analysis explores both the cradle-to-cradle concept and the SSD Framework through the lens of the five level framework, with a specific focus on the opportunities for synergies in applying the two concepts. This addresses the following research question: how can the cradle-to-cradle concept be framed in a way that supports strategic sustainable development?

System

Both FSSD and cradle-to-cradle are based upon study of the systems of society within the biosphere with the intention of sustainable development within those systems. Certain concepts are shared, although there are important distinctions in terms of the understanding of interactions between those systems.

The systemic view includes questions of energy, stocks and flows of materials, nested systems and interactions between complex systems – both biological and technical. These aspects are all tied to the societal infrastructure, the economic system in place and to questions related to transportation.

The concept of biological and technical metabolisms, and closing of material loops within human society, is shared by both cradle-to-cradle and the FSSD. Both approaches allow for the use of synthetic substances and substances extracted from the earth's crust as long as they are re-integrated into closed loop cycles and remain in use within society.

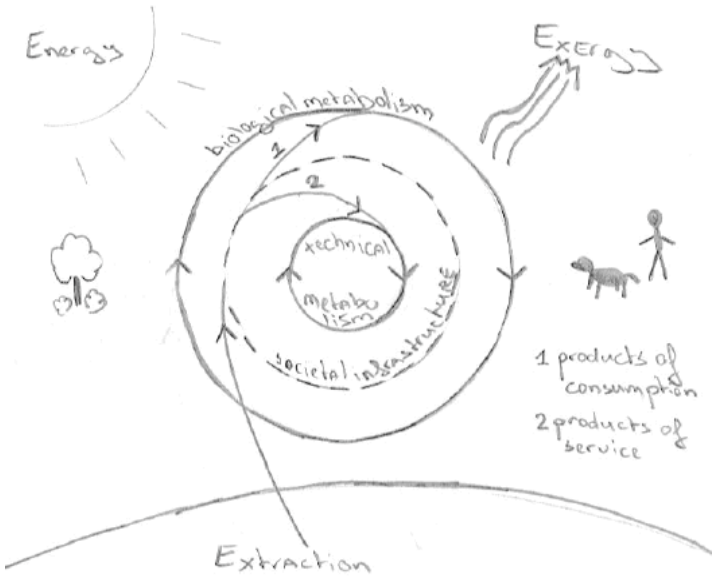


Figure 2. System including technical and biological loops: society within the biosphere.

Although the concept of closed loops is shared, cradle-to-cradle and FSSD frame the creation of closed loop cycles in different ways in relation to the larger system. Cradle-to-cradle, with its focus on eco-effectiveness, seeks to redefine the concept of waste to frame wastes as materials that provide value to systems external to the boundaries of the system under consideration. In this way, while working towards eco-effectiveness, at times cradle-to-cradle even encourages the production of 'wastes' because they produce value for another system. In this case, cradle-to-cradle explores the opportunities for positive effects on the external system, whereas FSSD focuses on eliminating contributions to degrading the system.

This distinction is subtle, but important, as cradle-to-cradle tends to focus on creating positive effects, and does not include clear criteria or guidelines to ensure systematic analysis that eliminates the creation of negative effects to the larger system. FSSD, on the other hand, provides clear criteria based on the current scientific understanding of the natural systems and lends itself to the analysis of scale and equilibrium between the systems of society and the biosphere. Both the creation of opportunities and adherence to basic sustainability principles are crucial to sustainable development over

the long-term and cradle-to-cradle together with the FSSD cover both those aspects.

Cradle-to-cradle specifically states that the use of toxic materials is acceptable within closed loops (Braungart et al. 2007). This raises questions related to the second law of thermodynamics, as all matter tends to disperse and some toxic materials are best phased out entirely.

Finally, searching for positive opportunity in design without a rigorous decision-making process leaves potential for problem displacement and problem shifting at the larger systems level. Cradle-to-cradle is based in systems understanding, and the FSSD provides the systematic approach to apply the concept in a strategic way with the larger purpose in mind.

Success

Success within the SSD Framework is delineated by the four sustainability principles introduced in section 3.1.2. Cradle-to-cradle also has principles of success, and they are:

- Waste = Food
- Use solar income
- Celebrate Diversity

(McDonough and Braungart, 2002a)

These cradle-to-cradle principles overlap substantially with the FSSD sustainability principles, and move in the same direction, as they are also principles for a sustainable society grounded in an analysis of the same systems. The main difference identified, is that the FSSD principles are designed specifically for backcasting, which means that they have been scrutinized and improved to meet the following criteria as closely as possible: concrete, science-based, non-overlapping, general, necessary and sufficient (Robèrt et al. 2004). As such, they have a number of advantages in the context of decision-making for sustainability. They are sufficient and systematic, and analysis of decisions against the sustainability principles means that all aspects of sustainability are covered. In addition, they are concrete and general enough to be applied in any situation and to analyze specific decisions against. The cradle-to-cradle principles, on the other hand, are not systematic or concrete enough to guide specific decisions. However, they are appealing, easily understood and communicated, and

they add colour to the understanding of the system and an appealing description of success. They trigger creativity and provide inspiration for the design of specific scenarios with the potential to move towards compliance with the FSSD sustainability principles at a societal level, although they are not designed to scrutinize decisions against.

Strategy

Cradle-to-cradle guidelines are essentially design guidelines based on the tenet 'learning from nature' (Korhonen 2004). The implied strategy to implement the concept is backcasting from scenarios, based on this positive metaphor.

This metaphor can be useful to inspire, although has many limitations in practice. Specifically, there is no analog of photosynthesis in the industrial world and exergy from outside the system is required to recycle (Ayres 2004). The current reality of the industrial system is not such that it mimics the ecological system, and therefore, the positive metaphor can encourage growth before basic redesign constraints are met on a societal level. The metaphor can certainly be useful in stimulating creativity, and engaging people, especially with emphasis on design for integration into cycles, although questions of scale and systems are crucial and technical issues abound. In this context, the importance of systematic and concrete criteria, such as the sustainability principles, provide a strong complement to the process, allowing specific scenarios to be scrutinized against the sustainability principles, and leading to more up-stream solutions.

Cradle-to-cradle strategy places strong emphasis on seeking opportunities to create, and for regenerative options. Tools and strategic approaches, such as the fractal tool (outlined in Appendix B) shift attention from negative value judgements to questions of quality. The concept of quality is central to application of cradle-to-cradle, with specific focus on the quality of materials used. In the words of the authors: "Cradle-to-cradle design enables the creation of wholly beneficial industrial systems driven by the synergistic pursuit of positive economic, environmental and social goals (Braungart et al. 2007). The maintenance of resource quality and productivity is a necessary characteristic of eco-effective industrial systems (Braungart et al. 2007).

This focus on quality is apparent in the academic publications on cradle-to-cradle implementation strategy, as they have a strong focus on product

development and material replacement, with planning being done at the level of the individual organization. In particular, the strategy that Braungart and McDonough provide to businesses to work towards eco-effectiveness, focuses on product design, and starts with four steps outlining actions to lead towards material replacements in existing products (see Appendix C for full strategy). Only the last step looks at the larger system and calls for a reinvention of the relationship between the product and the customer (McDonough, Braungart and Bollinger 2007). This does not necessarily align with the strategy of backcasting from an overall sustainability perspective and systems approach, where investments into infrastructure for the collection of products have the potential to be more strategic steps than material replacements in existing products. From a strategic sustainable development perspective, material replacement with safe/natural materials is not a strategic step unless it contributes to the ultimate aim of achieving effectiveness at the level of the scale and function of the material products that society is producing with the goal of meeting human needs.

The cradle-to-cradle strategy puts a negative focus on efficiency strategies, and highlights effectiveness as the best option. The authors stress that strategies of reduction and minimization are not even steps in the right direction unless they contribute to the ultimate aim of achieving cyclical material flow systems that maintain material quality and productivity over time (Braungart et al. 2007). Although it is acknowledged that efficiency and effectiveness can be complementary strategies, the main focus of cradle-to-cradle is on effectiveness.

In cradle-to-cradle, eco-efficiency promotes incremental reductions in the ecological impact of industrial processes and products. While this type of incremental change has been a worthwhile and necessary initial step with regards to laying groundwork and getting hold of the "low-hanging fruits", it cannot be regarded as an end in itself or even a feasible long-term strategy (Braungart et al. 2007). This statement shows intent of applying a strategy for creating the 'right' things with respect to long-term, principle-based goals. Efficiency could provide the first steps, as long as it is a flexible platform for long-term success.

There is much potential to integrate the cradle-to-cradle and FSSD strategies, as the creative design of specific solutions and approaches is a crucial component of the backcasting from sustainability principles

approach. Integrating sustainability principles with the cradle-to-cradle strategy has the potential to ensure that the solutions designed are strategic steps towards sustainability at a systems level.

Complementary nature of cradle-to-cradle and the FSSD

FSSD is an inclusive approach to sustainable development, which is based upon backcasting from a desired future, structuring information in a systematic way to enable decision making, and incorporation of diverse tools and concepts as they support strategic goals. This provides an open approach with great flexibility in order to support sustainable development initiatives.

Cradle-to-cradle supports sustainable development by looking beyond the minimum requirements for survival and searching for ways to create opportunities. It holds a vision of human industry as a regenerative force and searches for ways to restore nature and create enduring wealth and social value (McDonough and Braungart 2002b). The tools and strategies applied trigger creativity and are based upon principles of success from the powerful positive metaphor 'learning from nature'.

Combined, these approaches have great potential to move society towards sustainability. The first stage of a paradigm shift is based in metaphor (Korhonen 2004), and cradle-to-cradle has the potential to engage and communicate this new paradigm to many people. FSSD has a structured planning and decision-making process to implement specific actions towards this new paradigm in a systematic way.

3.2 Implementation

3.2.1 Process

Complex systems require a planning process that is specifically designed for them, differing from approaches that are applicable for simple systems. The systems of an organization within society within the biosphere is an example of such a complex system. In the following section, the process of backcasting from principles for sustainability is being investigated.

Forecasting and Backcasting approaches

While traditional forecasts were increasingly failing to create good anticipations by the late 60's and early 70's, a new approach on strategic planning by using scenarios started at Royal Dutch/Shell. Two main things at Shell show a development on planning using scenarios: it shifted from "less on predicting outcomes and more on understanding the forces that would eventually compel an outcome"; and the shift to design scenarios aiming to support decision-makers by questioning their mental models (Wack 1985a 1985b).

This evolution shakes the paradigm of traditional scenarios only based on a probabilistic assessment to ones based on causal analysis. Different cause-effect relations were creating possible futures to happen, not the most likely one. Scenario analysis then broke with the pure rationalistic paradigm (van der Heijden 2005, 23-31) and moved to become explorative rather than predictive.

Backcasting is an approach that differs from forecasting by points described by Dreborg (Dreborg 1996), among them:

- Backcasting works in a context of discovery rather than a context of justification;
- Backcasting, when working with social issues, carries the principle of teleology (purposefulness) rather than simple causality.

Both approaches have in common that they operate by scenarios. Carlsson-Kanyama et al. (Carlsson-Kanyama 2008) defines three different scenario typologies:

1. Probable: predictive scenarios: Answering the question: What will happen? Methodologies such as forecasting models or trend extrapolations.
2. Possible: explorative scenarios. Answering the question: What could happen? Methods are based on `push' driving forces: causal analysis.
3. Preferable: normative scenarios. Answering the question: How a solution to a particular problem might look? Methods based on `pull' driving forces: a teleological analysis.

Taking all these typologies as valid, the question is to decide what questions should be asked when facing a specific situation. For our weather forecast, (1) can be chosen; for scenario planning at Shell, (2) was more adequate. When talking about strategy for sustainability, (1) will not serve us since the most probable scenario is only useful for mitigation purposes. We will then look at (2) and (3) by analyzing both what is possible and preferable.

Backcasting approaches already work this way by acknowledging that causality (2) has a role to play, but a *total causal model* (Dreborg 1996), as used in forecasting studies, needs to be complemented by a normative approach (3).

This normative approach in backcasting underlines the assumption that human intentions today influence the shape of the future, while forecasting usually only offers extrapolations of the past drawn by causal derivations. Backcasting is an approach that facilitates the creation of scenarios less bounded by the present, ones that are mental images of a “totally other" reality (Polak 1961).

Backcasting is a normative and goal-oriented process, intuitively the process we use to plan: “we do not so much predict the most likely future as articulate and intention, or set a goal, and then act to realize it" (Robinson 2003). By being goal-oriented, the process of developing scenarios does not come with an effort to justify the choice, but rather an effort of collective discovery, since in this case what matters are the ideas that can solve the question and not the pursuing of scientific validity (Dreborg 1996).

The development of society towards sustainability is influenced by many actors' actions and perceptions. If intention plays an important role on human behavior (Dreborg 1996), a shared intention (vision) is essential in organizations (Senge 1990, Collins 1994) or a society (Boulding 1988).

On these groups, the importance is not entirely on setting the goal, but also in the social learning process that allows the goal to be perceived as collective and instigate cohesion in acting (van der Heijden 2005). Backcasting together with using participatory processes can both contribute to social learning and to access this shared intention.

Participatory Backcasting

In planning in complex systems, backcasting is used in a way Robinson defines as a “second generation" form (Robinson 2003). The desired future is not determined in advance by experts and brought to the dialogue, but the analysis is an emergent property as the stakeholders engage in the process.

To define strategies for sustainability, both science and social participation are needed. The approach where the decision is typically science-centered and lies on the hands of experts often puts as secondary matters the social and cultural structure of the system. Include public participation has been, for this model, a matter of just informing rather than consulting (Street 1997).

Society within the biosphere is the complex system in which sustainability is addressed. To that complexity, a paradigm of optimizing the most efficient way of achieving a goal shifts for a paradigm of learning (Bagheri and Hjorth 2007) (Checkland 1981, 258) where collective learning is fundamental for the evolution of the system.

Focusing on systems that learn implies adopting a more integral theory of strategy (van der Heijden 2005, 34-50), a theory that focuses on acting while continuously learning from the feedback of our actions (Argyris and Shön 1978) and from the future as it emerges (Scharmer 2007).

Acknowledging the importance of a participatory process rather than a think-tank of experts, the focus shifts from scenarios (sustainability goals) determined in advance to become an emergent property of the consultation process (Carlsson-Kanyama 2008).

The role of science and boundary conditions

Natural sciences value the predictive approach. Laws in science are rules that models an event in a way that experiences always confirm it, until a better model takes its place (Kuhn 1962, Checkland 1981, 248-249). Gravity is a law because it predicts the behaviour of an object when we hold it a meter off the ground and drop it. A kid in high school, provided with some data, can give us a good prediction of the velocity of this object based on a Newtonian model.

Analog to this, principles of sustainability are based on the laws of thermodynamics. These laws are models that predict the future behaviour and can be considered the boundary conditions of how systems behave thermodynamically. Scientific studies have been made that defined principles of sustainability (Holmberg 1998, Holmberg and Robèrt 2000).

Currently no laws - as they are understood in natural sciences - can apply to social sciences. The simple fact that the agent observed re-creates his relationship to a situation by giving a different meaning *ad hoc*, an observer will never be able to have a detailed map of his state of mind in advance to predict his behaviour. “This kind of argument suggests that at best social systems will reveal 'trends' rather than 'laws' (Checkland 1981). The exploration of social systems is therefore more related to creating a process rather than trying to come up with crystallised laws. In addition, sustainability, especially social sustainability, is not an end-state or deterministic (Korhonen 2004). This suggests that a process of social learning, with broad stakeholder participation, is an essential strategy for any process of sustainable development (Bagheri and Hjorth 2007).

The use of the method of science alone in planning in complex systems has its limitations when the complexity of the system increases (Checkland 1981, 60). For instance social sciences, as opposed to natural sciences, has to consider more undefined variables and relationships since a component of the study “is the individual human being, and even if we depersonalize him as an 'actor' in a 'role' he will be an active participant in the phenomena investigated, attributing meanings and modifying the situation in a potentially unique way" (Checkland 1981, 69).

The fact that a system is too complex for a pure scientific analysis does not mean that science does not apply to them. Science plays a role of identifying first-order principles to support the creation of more customized and shared principles. In social sciences, Holmberg and Robèrt use basic human needs as a generic first-order principle from which social tailor-made principles could be analysed against (Holmberg and Robèrt 2000). This first-order social principle is explicit as the fourth sustainability principle.

Backcasting from principles relies on science and can be seen as predictive as it limits the possible scenarios in the future, but it actually only displays the boundaries within which many scenarios are possible and creativity is allowed. This sets up a common ground for the development of scenarios

while not being predictive. The general purpose of the analysis is not to predict, but to assess feasibility of desired outcomes (Robinson 2003), even if the outcomes are conditioned to principle boundaries.

When setting up an intention for backcasting is important to analyse if the vision or any action step towards it contradict any principle, if it goes beyond the boundary conditions. Within those boundaries, space is open to any development and creation. When creating scenarios and processes of a future state that is at least sustainable, it is important to acknowledge these boundaries to be able to create within them. This is the basis of what Robèrt et al. (Robèrt et al. 2004) call “creativity within constrains". Being creative within constrains means, for example, that one knows the laws of nature well enough to be able to engineer a machine heavier than air and put it to fly.

To have the overall description of the system set into principles does not aim to be a platform for solutions in complex systems such as sustainability (Holmberg and Robèrt 2000). Definition of principles is rather a strategy to help make the process of planning simpler, but without reductionism (Broman et al. 2000).

Sustainability Principles and Principles for Design

Besides the minimum conditions proposed by science – the sustainability principles – there is a need to define local design principles - and therefore the boundaries - that the collective representing the system wants to set for them. Those second set of principles – principles for design – work as a guideline of the future state of the system designed by its stakeholders, a form of effective social engagement (Banathy 1998). This collective vision of shared principles set up the creative tension needed to a creative design of solutions.

Dee Hock defines those set of principles as: “A clear behavioural aspiration of the community, a clear, unambiguous statement of a fundamental belief about how the whole and all the parts should conduct themselves in pursuit of the purpose” (Hock 1999). He elaborates to say that they are “a living set of beliefs capable of evolving with the participation and consent of the community (…) they give no instruction or method” also, there is room for paradox and conflict within the principles although they should constitute a coherent, cohesive, body of belief.

Dreborg (Dreborg 1996) suggests that backcasting should include a view on the role of values. Street (Street 1997) says that “economic, environmental and social goals are value laden, and thus local values and knowledge need to be integrated into strategies for sustainability".

Principles for design work as a map of shared values and metaphors that represent the alignment towards a vision of the future. They are created to show the most inspiring picture of the future state.

On sustainability principles, details of possible future states are not set, so there is enough flexibility to allow creativity in planning and mid-course corrections while acting. Not trying to start agreeing on details of a desired future state prevents the group of getting in an infinite jigsaw puzzle-solving exercise (Robèrt et al. 2004). This approach has no strategy and low value.

Both science-based and stakeholder-defined principles are important in strategy as they support respectively systematic planning and creativity in design. Understanding the system in terms of both science and the role of people within it enhances the emergence of a collective desired scenario (Street 1997).

At this point, scenario analysis can be created within those boundary conditions and any method can be used to shape those scenarios. With social principles defined by a participatory backcasting, it is possible to create multiple scenarios as a group or even have one or more smaller groups to define scenarios and offer them to the whole group.

Backcasting the cradle-to-cradle concept

Cradle-to-cradle is a question of designing systems that serve a purpose while being in partnership with nature. To design a system that serves both humans and nature (McDonough and Braungart 2002a, 156) requires us to set an intention that is beyond simple causal implications. Backcasting, being “explicitly normative and design-oriented" (Robinson 1990) is therefore a suitable approach for cradle-to-cradle.

According to McDonough and Braungart (McDonough and Braungart 2002a, 183), “it is important (...) that signals of intention be founded on healthy principles" to make sure we do not substitute one problem for another. This approach is aligned with using principles for design and,

complemented with the use of sustainability principles for backcasting, provide a robust planning process backcasting from the cradle-to-cradle concept. Figure 3 represents the steps for implementation.

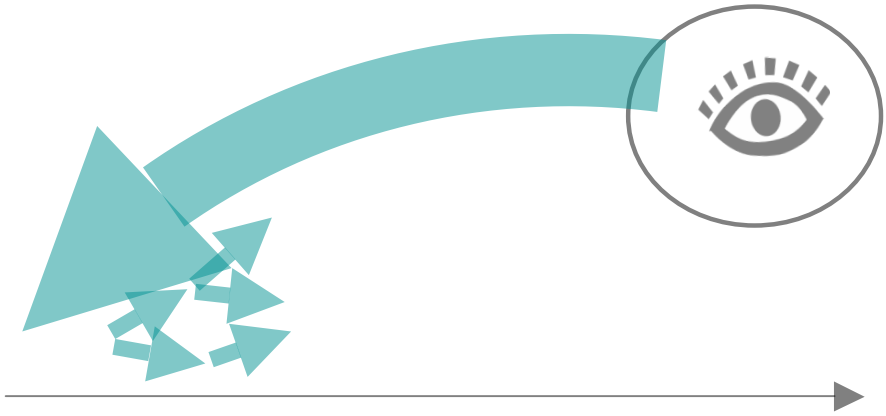


Figure 3 – Process of backcasting from a designed success state.

I) Designing principles of a future state.

The concept of cradle-to-cradle defines inspiring guidelines and metaphors for the design of products and processes for sustainability. Together with social principles derived from stakeholder engagement, the design principles of a future society or organization are in place.

II) Analysis of current reality and creating compelling measures.

By looking at current reality from the lens of the sustainability principles it is possible to classify what is current that is going to the wrong direction of sustainability and should be addressed. On the other hand, compelling measures based on the principles design bring a totally other perspective on possible actions to the desired state.

III) Setting priorities.

To set priorities it is important to see the compelling measures towards the vision of the future through the lens of the boundary conditions and apply

the prioritization questions: is it going in the right direction?; is it a flexible platform?; and is it a good return on investment?

IV) Creating a plan of action.

To solidify the compelling measures after prioritized, it is important to institutionalize the action, by creating a plan of implementation.

3.2.2 Case Study

Current Reality of cradle-to-cradle implementation in the NL

The cradle-to-cradle concept has drawn a lot of attention in the Netherlands. After the broadcasting of a very compelling documentary on the concept in November 2006 a lot of initiatives have seen the light in order to implement the concept. In this process, a gap was identified between understanding of the system and actions and tools. In particular, there is a lack of shared understanding of success (at a principle level) and clear strategy for selecting actions and tools in line with a shared vision of success. In the context of the Netherlands, actions and tools are being selected and implemented in an ad hoc way, and there is a general uncertainty about ways to develop integrated strategies to work towards cradle-to-cradle. There is a general concern that unless clear strategies and concrete successes are achieved, this surge of enthusiasm around the cradle-to-cradle concept will remain a hype fail to institutionalize real change at the level of individual organizations.

On the positive side, there is an enthusiasm and momentum behind the cradle-to-cradle concept, and people are energized to work in new and innovative ways to implement it. Research institutions and government are devoting time and money towards developing the concept (personal communications, Dick Thesing, Paul Levels, Wouter Kersten 2008). Also, the networks are bringing together people from different sectors of society to interact in unconventional ways working towards sustainable development.

The main opportunity that we have identified, is to work towards building a framework around which Dutch society can have a collective and constructive dialogue about success, as well as to develop an understanding

of how to implement actions at an individual level in working towards success at the societal level.

Current Cradle-to-cradle planning in Limburg

The province of Limburg in the Netherlands is approaching regional development from the cradle-to-cradle perspective and the 2012 Floriade conference has the goal of being an entirely cradle-to-cradle event (personal communications: Dick Thesing, Paul Levels and Harma Albering 2008). These projects are in the early stages, and interviews made with some of these groups showed that a strategic perspective would be beneficial when planning towards the objectives proposed.

The case study organization that we have been looking at is the Province of Limburg, the body that is responsible for the most Southern province in the Netherlands. The cradle-to-cradle concept is, compared to the rest of the world, very popular in the Netherlands (see cradle-to-cradle hits on language on google) and, within the Netherlands, the region of Limburg is the place where most activity takes place around cradle-to-cradle.

At the moment that we are writing this thesis, the province is in the midst of a visioning and strategic planning process in order to transition the region towards a more sustainable society, inspired by the cradle-to-cradle concept. On March 28 a multi-departmental brainstorm has taken place in which actions and measures have been suggested on the strategic, tactical and operational level, split up in quick wins, mid long term goals, and long term goals. The main challenge that they have been facing after going through this process is an identified gap between goals, ideas and a good project planning. The participants have succeeded in having a productive brainstorm session with a valuable outcome and facing the challenge of making the translation to a clear action plan.

Current Cradle-to-Cradle strategic sustainability planning process in Limburg

Sustainable development is one of the strategic priorities of the Province of Limburg. At several departments of the organization, efforts are being made in order to integrate sustainability in decision and policy making, on the strategic, tactic and operational level. In the organization, the awareness exists that a structured and rigid approach towards sustainability is needed in order to make real progress. All too often, the strategy currently used to

tackle environmental problems and identify sustainable solutions focuses on improving the efficiency of production processes and products in small, incremental steps (Levels 2008).

Especially at the department of environment and sustainable development (MDO), strong incentives exist to look for ways to increase awareness and improve decision making based on sustainability and cradle-to-cradle. Besides the use of their own staff, external parties have been hired to help in making this transitional change within the organization.

At the end of 2008, the department of MDO has chosen to embrace the cradle-to-cradle principles and to tailor make them for the Province of Limburg. On of the Province's deputies has explicitly agreed with the principles and signed them to show his commitment.

For the Province of Limburg, the cradle-to-cradle framework means:

- we are native to our place;
- our waste is our food;
- sun is our income;
- our air, soil and water are healthy;
- we design enjoyment for all generations.
- provide enjoyable mobility for all.

When working for the provincial government, there is a tension between policy makers and executors. The policy makers are elected every four years and for that reason enjoy a reduced incentive for being a visionary leader. Members of the executive department are for this reason facing the challenge of translating measurement that have clear advantages and that are strongly preferable in the long-term into attractive alternatives for short-term decision makers.

As one of the participants in the workshop indicated; "It is important to create a long-term horizon from which a route can be clearly defined. This is crucial in the attainment governmental momentum." This is backed up by the experience of another participant; "Working from a vision (…) is absolutely necessary to give direction and consistency to sustainable development in our region."

A shared vocabulary and language are required to make true progress in sustainable development. This enhances the chances that the goal and

vision are not solely shared but also agreed upon and understood; “In order to create commitment, there needs to be a shared understanding of success.” “Instead of jumping to solutions and quick fixes we first need to determine the constraints within which we are acting and develop the targets we want to achieve.”

Enhancing the decision-making process with the FSSD

The goal for the workshop was to introduce a decision-making process for strategic planning towards sustainability. The workshop design was such that we first created awareness on the complexity that a systemic approach for planning towards sustainability implies and that means for dealing with that have to be chosen accordingly. This led to the introduction of the backcasting from principles. The province itself was already using the cradle-to-cradle principles and other guidelines as sources of inspiration and together we first looked at how these in themselves where of value. After that, we looked at a set of criteria that principles for sustainability can be scrutinized against, followed by the introduction of the sustainability principles. The participants learned how to value the cradle-to-cradle principles as a good way to communicate and inspire people and drew the conclusion that the sustainability principles are most valuable when, after a period of brainstorming and creativity, they were applied for planning purposes and to determine if and in what way the brainstormed ideas could best come to life. They practised on how to use the prioritization questions and are now in the process of seeing how to incorporate the backcasting approach in their own decision-making process. Insights from the workshop include that backcasting can be an “aid in the development of a policy for a sustainable Limburg”. It gives a ‘better overview of alternatives and a stronger coherence in planning.” Furthermore it was indicated that “mirroring both your current reality as well as your vision against the same set of principles can provide you with a clear action plan“ towards becoming a more sustainable region. “It takes a lot of time to frame sustainability” and “framing sustainability is something that you need to do together.” The participants have gained insight in the value of backcasting as a process for making choices in a grounded way and recognized that is provides a clear mental model that can lead you in the development of your policies.

4 Discussion

Results support the hypothesis that backcasting from principles is a systematic and elegant way to strategically implement cradle-to-cradle, especially in terms of contributing to a systematic implementation of cradle-to-cradle with respect to sustainability.

4.1 Principles and Process

A distinction was made between principles for design and principles for decision-making. This insight provided clarity to the process design, and helped to frame both the cradle-to-cradle concept, and the FSSD, in ways that highlight their strengths in terms of moving society strategically towards sustainability. This helped to capitalize on the strengths of both concepts and sets of principles to explore where they best fit within the backcasting process. Also, this clarified interviews and conversations about the relative benefits and downfalls of framing sustainability in terms of restrictions or in terms of opportunities. The sustainability principles, framed as constraints, provide robust decision-making criteria, and the cradle-to-cradle principles, framed as opportunities grounded in metaphor, provide design principles to colour creativity. The FSSD is most effectively implemented with a colourful and vivid shared vision, and the cradle-to-cradle concept can trigger creativity towards that vision. Results support that cradle-to-cradle could be most effectively implemented when complemented with a robust and systematic decision-making framework to ensure that steps taken are strategic from a systems perspective of sustainability.

The distinction between decision-making and design principles was supported by the participants of the workshop through conversations exploring the potential uses and value of the various sets of principles for their sustainable development projects. The participants saw a great deal of value in working with the cradle-to-cradle principles. They described these principles with words including: ambitious, challenging, appealing, start a transition and vision. These descriptions support the use of such principles in communication to trigger the creation of a vision, and also to gain a shared commitment to the sustainable development process. Descriptions of the sustainability principles included the words: concrete, scientific, academic and ‘smell the numbers’. It was also suggested to ‘prioritize

actions based on the rules' highlighting that system boundaries, or 'rules' have an important place in the selection and strategic prioritization of specific actions.

These results indicate the potential for a combined cradle-to-cradle and FSSD approach to provide a bridge from inspiring concepts and metaphor to strategic implementation. This mirrors a the stages for a paradigm shift proposed by Korhonen (2004), in which first stages in understanding of a new paradigm are metaphor based, and further stages are based upon specific measures, indicators and implementation (Korhonen 2004).

In terms of the process proposed, workshop feedback confirmed that backcasting, integrating both sustainability principles to aid in decision-making and cradle-to-cradle principles to guide design, is an approach that makes sense to professionals working to implement the cradle-to-cradle concept in their sustainable development projects. The process was well received, and project leaders and managers have committed time to further develop and explore opportunities to further implement this process in their specific projects. Participants also expressed that backcasting should be integrated as early as possible in the planning process, and shared from the strategic down to the operational levels.

4.2 Workshop implementation insights – the social learning process

The process of the workshop itself also provided some key insights into the application of the process in practice. During the workshop, researchers noticed anxiety and impatience of some participants during the first steps of coming to the systems understanding. Upon reflection, it is hypothesized that in sustainable development, the urgency of the sustainability challenge can trigger the desire to move as quickly as possible and leaders can tend to hold emotional attachment to their work. As a learning point, it is important to be aware of this while designing the process, and the interventions. One participant in particular shared the insight that 'it takes a lot of time to explain sustainable development' and 'you have to do it together'. The group social learning process depends on the comfort level of the participants, and the shared understanding of the system, so the importance of this step is not to be overlooked.

4.3 Societal transition towards sustainability

Interview results support the insight that current cradle-to-cradle implementation efforts lack a systems overview and strategic approach. Questions to at the systems level gave responses that returned to the drill-hole. Responsibilities for certain key aspects with respect to the systemic implementation were shifted to other parties. 'I trust that someone else will take care of the energy problem'. Overall, the impression was that cradle-to-cradle efforts are missing opportunities for strategic leverage points at the systems level, and that partnerships should be further explored in the context of a dialogue about the societal infrastructure required to fully implement the concept.

4.4 Validity and significance of results

The situation within the Netherlands is unique, as there is currently a hype surrounding the cradle-to-cradle concept. Application of the process could be different in other societal and cultural contexts, although within the scope of the study, results provide valuable insights.

The research is significant as an example of how inspiring principles and concepts, such as the cradle-to-cradle concept, can be integrated with backcasting in a robust and strategic approach to sustainable development.

5 Conclusion

Both design and decision-making are key components within the process of backcasting from sustainability principles, and each can be supported with complementary and distinct sets of principles. The distinction between these sets of principles clarifies the value of each within the process of moving strategically towards sustainability. This enables the design of a process that brings the strengths of both sets of principles and approaches to support a strategic transition towards sustainable development.

Sustainability principles need to be coloured by creativity, and principles of design, such as those provided by cradle-to-cradle, can help to engage people in that creative process. In addition, principles of design are best implemented in conjunction with a robust decision-making framework, based on sustainability principles. Both of these strengths have been integrated into the process of backcasting, which has been framed in a way to focus on a social learning process. Results indicate potential for this process to support strategic steps towards sustainability.

Recommendations for future research include the application of the process developed to a multi-stakeholder dialogue to design a societal infrastructure to close material loops. In addition, follow up research with the Province of Limburg could provide insight into the prioritization of actions within the process proposed, and the implementation of actions.

References

Argyris, C. and D. Schön. 1978. *Organizational Learning: A Theory of Action Perspective.* Reading MA: Addison Wesley.

Ayres, R. U. 2004. “On the life cycle metaphor: Where ecology and economics diverge.” *Ecological Economics* 48: 425-438.

Bagheri, A. and P. Hjorth. 2007. "Planning for Sustainable Development: a Paradigm Shift Towards a Process-Based Approach." *Sustainable Development* 15: 83-96.

Banathy, B. H. 1998. "Evolution Guided by Design: A Systems Perspective." *Systems Research And Behavioral Science* 15: 161-172.

Boulding, E. 1988. "Image and Action in Peace Building." *Journal Of Social Issues* 44: 17-37.

Braungart, M., W. McDonough and A. Bollinger. 2007. "Cradle-to-Cradle Design: Creating Healthy Emissions - a Strategy for Eco-Effective Product and System Design”. *Journal of Cleaner Production* 15(13-14): 1337-1348.

Broman, G., J. Holmberg and K.-H. Robèrt. 2000. “Simplicity without Reduction: Thinking Upstream Towards the Sustainable Society.” *Interfaces: International Journal of the Institute for Operations Research and the Management Sciences* 30(3).

Capra, F. 1996. *The web of life : a new synthesis of mind and matter.* London: Flamingo.

Carlsson-Kanyama, A., K.-H. Dreborg, H. Moll and others. 2008. “Participative Backcasting: A tool for involving stakeholders in local sustainability planning.” *Futures* 34-46.

Checkland, P. 1981. *Systems Thinking, Systems Practice.* John Wiley and Sons.

Collins, J. C. and J. I. Porras. 1994. *Build to last: successful habits of visionary companies*. New York: HarperBusiness.

Dreborg, K.-H. 1996. “Essence of Backcasting.” *Futures* 28(9): 813-828.

Hock, D. 1999. *Birth of the chaordic age.* San Francisco: Berrett-Koehler.

Holmberg, J. 1998. “Backcasting: A Natural Step in Operationalising Sustainable Development.” *Greener Management International* 30-52.

Holmberg, J. and K.-H. Robèrt. 2000. “Backcasting from non-overlapping sustainability principles – a framework for strategic planning.” *International Journal of Sustainable Development and World Ecology* 291-308.

Holling, C. S. 2004. "From Complex Regions to Complex Worlds." *Ecology and Society* 1(9).

Korhonen, J. 2004. "Industrial Ecology in the Strategic Sustainable Development Model: strategic applications of industrial ecology." *Journal Of Cleaner Production* 12: 15.

Kuhn, T. S. 1962. *The Structure of Scientific Revolutions.* The University of Chicago Press.

Laszlo, E. 1996. *The Systems View of the World: A Holistic Vision for Our Time*. New Jersey: Hampton Press Inc.

Levels, P. and H. Albering. Personal communication. Feb 1, 2008.

Levels, P. Flyer cradle-to-cradle Province of Limburg, 2007

McDonough, W. 1998. "Essay: A Centennial Sermon: Design, Ecology, Ethics, and the Making of Things." *Perspecta* 29: 78-85.

McDonough, W. and M. Braungart. 2002a. *Cradle to Cradle : Remaking the Way We Make Things*. New York: North Point Press.

McDonough, W. and M. Braungart. 2002b. "Design for the Triple Top Line: New Tools for Sustainable Commerce." *Corporate Environmental Strategy* 9(3).

Mitroff, I. and H. A. Linstone. 1993. *The unbounded mind : breaking the chains of traditional business thinking*. New York: Oxford University Press.

Polak, F. 1961. *The image of the future.* A. W. Sythoff/Oceana.

Quinn, D. 1992. *Ishmael : an adventure of the mind and spirit : a novel*. New York: Bantam books.

Ring, I. 1997. "Evolutionary strategies in environmental policy." *Ecological Economics* 23: 13.

Robèrt, K.-H. 2000. "Tools and concepts for sustainable development, how do they relate to a general framework for sustainable development and to each other." *Journal of Cleaner Production* 10: 243-254.

Robèrt, K.-H., G. Broman, D. Waldron and others. 2004. *Strategic Leadership Towards Sustainability.* Karlskrona, Sweden: Blekinge Tekniska Högskola.

Robinson, J. B. 1988. "Unlearning and backcasting: Rethinking some of the questions we ask about the future." *Technological Forecasting and Social Change* 33: 325-338.

Robinson, J. B. 1990. "Futures Under Glass: A recipe for people who hate to predict." *Futures* 22(8): 820-841.

Robinson, J. B. 2003. "Future subjunctive: backcasting as social learning." *Futures* 35: 839-856.

Scharmer, C. O. 2007. *Theory U: Leading from the Future as It Emerges.* Cambridge: The Society for Organizational Learning.

Schumacher, E. F. 1973. *Small is beautiful : economics as if people mattered*. New York.

Senge, P. 1990. *The fifth discipline: the art and practice of the learning organization.* Doubleday/Currency.

Senge, P., G. Carstedt and P. Porter. 2001. "Innovating our way to the next Industrial Revolution." *MIT Sloan Management Review* 42(2): 24.

Street, P. 1997. “Scenario workshops: A participatory approach to sustainable urban living?” *Futures* 29(2): 139-158.

Thesing, D. Personal communication. January 29, 2008.

van der Heijden, K. 2005. *Scenarios: the art of strategic convesation.* West Sussex: John Wiley and Sons.

Verfaillie, H.A. and R. Bidwell. *Measuring Eco-Efficiency: A Guide to Reporting Company.*

Wack, P. 1985a. "Scenarios: uncharted waters ahead." *Harvard Business Review* 63: 73-89.

Wack, P. 1985b. "Scenarios: shooting the rapids." *Harvard Business Review* 63: 139-150.

World Commission on Environment and Development (WCED). 1987. *Our Common Future (The Brundtland Report)*. Oxford University Press: Oxford.

Appendices

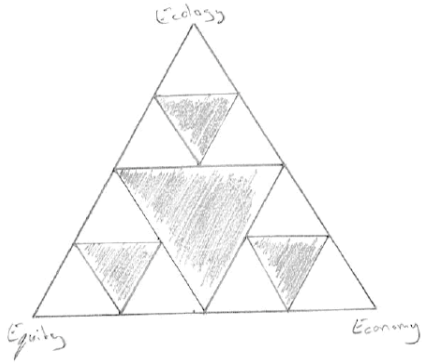
Appendix A: List of interviewees: Jan 28-Feb2:

Name	Organization	Location	title/level of society
Martje Meerendonk	10Flowers	Heemstede	Entrepreneur / small business
Leo Baas	Erasmus University	Rotterdam	Professor of Industrial Ecology/ academia
Dick Thesingh	Chamber of Commerce	Venlo	Director of the Chamber of Commerce / government
Ernst Vuyk	Ecofys	Utrecht	Renewable energy consultant / international consultancy
Lammert Hettema	Interface Europe	Scherpenzeel	Large business
Gijsbert Korevaar	TU Delft	Delft	Director of the Industrial Ecology Programme /

			academia
Onno van Sandick	Ministry of VROM	The Hague	National Government
Alexander van de Beek	Innovate Consulting	The Hague	Business Consultant / small business
Tammo Oegema & Kim Nackenhorst	IMSA	Amsterdam	Sustainability Consultants / Medium sized business
Annemarie van Doorn	ABN AMRO	Amsterdam	VP Sustainable Development / large business (financial institution)
Wouter Kersten	Enviu	Rotterdam	Academia/ small business, entrepreneur
Paul Levels & Harma Albering	Province of Limburg	Maastricht	Provincial Government
Harry Rutten	DSM	Maastricht	Chemical Industry

Appendix B

Cradle-to-Cradle Thinking



Eco-effectiveness is in the core of cradle-to-cradle thinking with which it looks for opportunities to create. The tool that is currently most used to provoke and implement cradle-to-cradle thinking is the fractal triangle (Appendix i). It is used to show how ecology, economy and equity are interconnected and to find out how value can be generated in each category. In the planning process for a product or system it is used to optimize and maximize value in all areas of the triangle. (McDonough and Braungart 2002b) In the experience of McDonough and Braungart, the most fruitful insights are discovered "where design decisions create a kind of friction in the zones where values overlap" – so called ecotones which are ripe with business opportunities (McDonough and Braungart 2002b). What characterizes the fractal tool is that it evolves around the intention of the designer by shifting the focus of the design process from negative value judgments to questions of quality. (McDonough and Braungart 2002b) All of the questions asked in the process present an opportunity for creating value. Together, they signal the possibility of acting with positive intentions across a wide spectrum of human concerns. Such intentions introduce a new standard of product quality, performance and success (McDonough and Braungart 2002b).

Cradle-to-cradle: design and strategy

McDonough and Braungard [p. 166-181]{mcdonough02} suggest the steps: (1) get “free of" known culprits; (2) follow informed personal preferences; (3) creating a “passive positive" list; (4) activate the positive list; and (5) reinvent.

1. Step 1: Get “free of" known culprits.

This stage refers to the removal of dangerous substances when designing a product, so the creation of new products pass by a crude filter of “obviously harm substances" [p. 168]{mcdonough02}. This stage works like a checklist: the more we know about substances, bigger the list of culprits.

2. Step 2: Follow informed personal preferences.

Because it is nowadays impossible to have mapped either the exact impact of a substance on humans or nature, or the process through which they are produced, cradle-to-cradle authors say that decisions about materials comes down to *personal preferences* {braungart07}. When facing decisions to choose between two less than ideal paths, a designer should look at his preferences on (1) ecological intelligence; (2) respect; and (3) delight, celebration and fun [p. 171-173]{mcdonough02}.

Based on their own preferences, designers and decision-makers would basically choose between what is available to their

knowledge right now, relying on what he personally considers a better trade off. An eventual support from regulatory agencies or stamps such as the Forest Stewardship Council seal of approval when choosing your wood supply or the Fair Food logo when buying your groceries.

3. Step 3: Creating a “passive positive" list.

According with the authors, this is when one stops to only rely on existing information and starts to actively redesign. The questions and considerations are, however, relying on known issues. A “potential for ozone layer depletion" [p. 175]{mcdonough02} would not be an issue at the time CFC started to be used.

This step also assumes the possibility of having detailed information on every substance used (toxicological, eco-toxicological, persistence in nature, etc). A detailed and shared database of information about substances available could be an asset for decision-making process. Once done, the analysis would be restricted to the interaction between substances, another hard work endeavour, but also more room for collaborative data-sharing. These could be used for a collective active design towards eco-effectiveness, but basically using known issues of a shared database.

4. Step 4: Activate the positive list.

This step is an optimization of the passive positive list {braungart07} in a way that you start designing from scratch and choose materials from your preferable list.

While eco-effectiveness at this point breaks the assumption that one organization or product is something to be fixed, it is clear that every product and process cannot be immediately redesigned. Start products and processes from scratch is not a viable strategy for most of the organizations trying to survive in the market economy. If this complete redesign is not possible immediately, how to make sure the other steps are in the right direction?

5. Step 5: Reinvent.

The last step on redesigning is about recasting the assignment, going from a product to the purpose of its creation and set up a new innovative and, of course, eco-effective way of seeing and producing it.

One example is a shift from a product-economy to a service-economy that would bring many advantages.

In this eco-effective industrial system, the amount of materials used in a product is no relevant compared to the design of this product in a way that the status of resource is maintained, allowing re-introduction of it into the cycle. {braungart07} The energy used to produce, transport and use the product in his first of future lives are, however, a relevant point. What is the balance between the maintenance of materials as resources and the amount of energy use to produce, transport and re-transport, etc?

When analysing (1), (2) and (3), it is clear that by just having a material pooling or lists does solve most of the problems for a decision-maker going to design in a system. Even when restricted to a product, the process to produce this product is yet not taken into account.

As we explored before, being prescriptive is not the better approach when dealing with complex systems. Being prescriptive, in this case, means that telling people what to do and what not to do has no fundamental difference when looked from a strategically planning perspective. Both are prescriptive methods and do not allow two important things: creativity on planning and mid-course correction when acting. On the other hand, once a clear strategic decision has been made and the process is down to the action's level, having specific directions on how to act is desirable.

Steps (4) and (5) proposed by McDonough and Braungart invite for creativity and innovation in design. It is a fact that, when facing unknown issues, creativity and innovation can emerge to bring a new horizon, a paradigm shift [p. 175]{kuhn62,mcdonough02}. Creativity and innovation are surely part of the strategy of becoming eco-effective, but it is not the strategy itself.

While innovation and creativity has a lot of trial and error, it is not limited to this process.

Being strategic means designing an overall process (policy, plans of action, etc) to achieve a desired state. People have the ability to recognize natural and social patterns to create scientific models or at least the insightfulness to create an educated guess that can support decision-making. When you have no idea where to start, than trial and error becomes an option.

The steps created by the authors are of great value as the first step to the design of a new product or process, but even a completely new endeavor does not come to be without a strategy. By the moment a scientist or designer tries, the response becomes data that allows a more intelligent approach to select the new tentative.

If working with a system already in place that cannot be started immediately from scratch, the decision-maker needs support to define, having his vision, the smartest next step in the right direction to fulfil it.

Fractal Triangle Questions

source: McDonough and Braungart 2002 - Design for the Triple Top Line

When **applying the fractal triangle** to our own projects, we begin asking questions in the extreme, lower-right corner, which represents the **Economy/Economy** sector. Here we are in the realm of extremely pure capitalism. (…) Moving to the **Economy/Equity** sector, we consider questions of profitability and fairness. (…) As we continue on to **Equity/Economy**, our focus shift more towards fairness – we begin to see Economy through the lens of Equity. (…) In the extreme **Equity corner**, the questions are purely social. (…) The **Equity/Ecology** sector (…) might explore the ways in which a product (…) could enhance the health of employees and customers. Continuing to **Ecology/Equity**, we consider questions of safety or fairness in relation to the entire ecosystem. In the pure **Ecology** sector (…) we try to imagine how humans can be "tools for nature". Shifting to **Ecology/Economy**, commerce re-enters the [ecological] picture. (…) Finally, we come to **Economy/Ecology**, where we encounter many questions that relate to the triple bottom line. Here the inquiry tends to focus on efficiency.

Economy – extremely <u>pure capitalism</u>

Can I make my product or provide my service at a profit?

Economy/Equity – <u>profitability</u> and fairness

Are employees producing a promising product earning a living wage?

Equity/Economy – <u>fairness</u> and profitability

Are men and women being paid the same for the same work?

Are we finding ways to honour all stakeholders, regardless of race, sex, nationality or religion?

Equity – purely social

Will the new factory improve the quality of life of all stakeholders?

Equity/Ecology – health of employees and customers

In what ways could the product enhance the health of employees and customers?

Ecology/Equity – safety and fairness in relation to the entire ecosystem

Will our product contribute to the health of the watershed?

Ecology – humans as "tools for nature"

Are we obeying nature's laws?

Are we creating habitat?

How can I create more habitat?

Do our designs create habitat or nourish the landscape?

Ecology/Economy – ecology from a commercial feasibility perspective

Is our ecological strategy economically viable?

Will our ecological strategy enable us to use resources effectively?

Economy/Ecology – Triple Bottom Line / <u>Efficiency</u>

Will our production process use resources efficiently?

Will our production process reduce waste?

Triple Top Line Questions

How can this project restore more landscape and purify more water?

How much social interaction and joy can I create?

How do I generate more safety and health?

How much prosperity can I grow?

How can I grow prosperity, celebrate my community, and enhance the health of all species?

Each of these questions presents an opportunity for creating value. Together, they signal the possibility of acting with positive intentions across a wide spectrum of human concerns. Such intentions introduce a new standard of product quality, performance and success.

Appendix

Five Steps to Eco-Effectiveness

Step 1. Get "free of" known culprits - Beginning to turn away from substances that are widely recognized as harmful is the step most individuals and industries take first as they move towards eco-effectiveness. … Bear in mind that positively selecting the ingredients of which a products is made, and how they are combined, is the goal. … Nevertheless, thee are some substances that are known to be bioaccumulative and to cause such obvious harm that getting free of them is almost always a productive step. These are what we call X substances, and they include such materials as PVC, cadmium, lead, and mercury. … The decision to create products that are free of obviously harmful substances forms the rudiments of what we call a "design filter": a filter that is in the designer's head instead of on the ends of pipes.

Page 166 r. 7-9; Page 166 r. 22-24; Page 167 r. 17-21; Page 168 r. 6-9

Step 2. Follow informed personal preferences - …we are standing in the middle of an enormous marketplace filled with ingredients that are largely undefined: we know little about what they are made of, and how. … But we must begin somewhere, and odds are that as an initial step, considering these issues and expressing your preferences in the choices you make will result in greater eco-effectiveness than had you not considered them at all.

Page 168; Page 169 r. 19-21; Page 170 r. 12-16

Prefer ecological intelligence - Be as sure as you can that a product or substance does not contain or support substances and practices that are blatantly harmful to human and environmental health.

Page 171 r. 3-6

Prefer respect – The issue of respect is at the heart of eco-effective design, and although it is a difficult quality to quantify, it is manifested on a number of different levels, some of which may be readily apparent to the designer in search of material: respect for those who make the product, for the communities near where it is made, for those who handle and transport it, and ultimately for the customer.

Page 172 r. 12-17

Prefer delight, celebration, and fun - Another element we can attempt to assess – and perhaps the most readily apparent – is pleasure or delight. It's very important for ecologically intelligent products to be at the forefront of human expression.

Page 173 r. 11-14

Step 3. Creating a "passive positive" list - …Once screened, substances are placed on the following lists in a kind of technical triage that assigns greater and less urgency to problematic substances:

Page 173.

Page 174 r. 4-6

The X list – Substances placed on the X list are considered highest priorities for complete phase-out and, if necessary and possible, replacement.

Page 174 r. 16-18

The gray list - The gray list contains problematic substances that are not quite so urgently in need of phase-out. The list also includes problematic substances that are essential for manufacture, and for which we currently have no viable substitutes.

Page 174 r. 18-121

The P list – This is our "positive list," sometimes referred to as our "preferred list." It includes substances *actively defined* as healthy and safe for use. In general, we consider:

- acute oral or inhalative toxicity
- chronic toxicity
- whether the substance is a strong sensitizer
- whether the substance is a known or suspected carcinogen, mutagen, teratogen, or endocrine disruptor
- whether the substance is known or suspected to be bio-accumulative
- toxicity to water organisms (fish, daphnia, algae, bacteria) or soil organisms
- biodegradability
- potential for ozone-layer depletion
- whether all by-products meet the same criteria

Page 175 r. 8-21

Step 4. Activate the positive list – Here's where redesign begins in earnest, where we stop trying to be less bad and start figuring out how to be good. Now you set out with eco-effective principles, so that the product is designed from beginning to end to become food for either biological or technical metabolisms. … We might be encoding information about all of the ingredients in the materials themselves, in a kind of "upcycling passport" that can be read by scanners and used productively by future generations. … A new building could be given an upcycling passport that identifies all the substances used in its construction and indicates which are viable for future nutrient use and in which cycle.

Page 177 r. 11-15; Page 178 r. 5-12

Step 5. Reinvent – This final step has no absolute end point, and the results may be an entirely different kind of product than the one you began to work on. But it will be an evolution of that product in the sense that it addresses the limitations you became aware of as you moved through the previous steps. Design is based on the attempt to fulfill human needs in an evolving technical and cultural context. We begin by applying the active positive list to existing things, then to things that are only beginning to be imagined, or have not yet been conceived. When we optimize, we open our imaginations to radically new possibilities. We ask: What is the customer's need, how is the culture evolving, and how can these purposes be met by appealing and different kinds of products or services?

Page 178; Page 180-181 r. 14-4