

Design and Decision Making: Backcasting Using Principles to Implement Cradle-to-Cradle

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Abstract: Human society is currently designed based on linear patterns, without concern for and interactions with the biosphere. The natural world works in cycles, and in order to interact with these systems in a sustainable way, the redesign of human society according to the paradigm of cyclical thinking is required. This paper explores the synthesis and synergies between the cradle-to-cradle concept and a Framework for Strategic Sustainable Development in the context of sustainable development. The research tests whether *Backcasting using Sustainability Principles is supportive to the implementation of the cradle-to-cradle concept* and draws on relevant literature as well as interviews with experts. Based upon this research a process tool is designed and tested within a case study. Results indicate that, when backcasting using sustainability principles, principles for design and principles for decision-making provide synergistic characteristics in the process of implementation. Inspiring design principles, such as the ones suggested by the cradle-to-cradle concept, provide powerful engagement for a social learning process that works towards sustainable development. A structured decision-making process based on backcasting using sustainability principles provides the constraints and criteria for robust decision-making along the journey.

Keywords: Strategic sustainable development, cradle-to-cradle, design, decision making, backcasting using sustainability principles.

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To our friends and family, for sending their support from three different corners of the world.

Executive Summary

Context

Sustainability-related solutions are calling for better design of social systems, organizations and communities while also challenging decision makers and managers to take immediate action when facing a complex issue. Concepts, frameworks and tools to support these actors have been explored over the years, evolving with the understanding of sustainable development itself.

Based on an assessment of the current reality in the Netherlands this work explores the complementarities based on the shared systemic view elaborated by both cradle-to-cradle and a framework for strategic sustainable development. In the Netherlands the cradle-to-cradle concept has been strongly explored, but not yet implemented on a relevant scale.

Shared Systemic View

The cradle-to-cradle concept and the framework for strategic sustainable development share both the understanding of a system of stocks and flows composed by human society within the biosphere, exploring:

- the dangers and advantages of extracted and synthetic substances;
- the sources of energy, biodiversity and closed loops;
- the role of human society.

The subtle differences between the two are what distinguishes their focus and indicate their complementary approach.

Synergies

Cradle-to-cradle provides a set of principles, framed in the positive, that support creativity when designing a future state or a product. Their metaphors inspire and guide participants in a system to define their future by exploring possibilities beyond the constraints of current reality. This process stretches a creative tension and allows the design of supportive innovations towards a totally different reality disconnected from the ‘good’ and ‘bad’ actions of today.

The framework for strategic sustainable development contributes to the effective application of a systems perspective of sustainability during process of designing and planning. By using robust, science-based principles framed in the form of system constraints, and specifically designed for decision making and prioritizing, the framework supports a systematic application of the cradle-to-cradle concept.

Case Study Application

Limburg, the most Southern province in the Netherlands, has developed their principles for sustainability based on the cradle-to-cradle principles. This paper asks: *How can the Province of Limburg plan strategically towards a future that is in compliance with those principles?*

By introducing a process of planning in complex systems called backcasting, the authors hosted a workshop at the Province of Limburg that confirmed the benefits of having principles of design based on metaphors that allow creativity together with robust scientific principles of sustainability to guide a systematic planning process and action prioritization. Participants stated that the process gives a “better overview of alternatives and a stronger coherence in planning”.

Conclusion

If the system – organization, community or society – moving towards sustainability is in need of innovation beyond the simple projection of present actions, there is a need for both systems design and systematic planning. The process of moving a system towards sustainability is complex and requires a specific approach.

This work supports the use of backcasting as a suitable approach for designing and planning in complex systems. Backcasting from a designed state of the future requires both design principles that allow for creativity and inspiration and scientific sustainability principles that frame the system and support systematic planning.

It is suggested that the approach to implementation should include a broad strategic perspective and focus on the learning aspect of the system. The cradle-to-cradle concept provides an inspiring set of design principles to work with in the design of this social learning process.

Author's Note

The process of writing this thesis as a collaborative group allowed each of us to develop and put into practice certain skills required to move society towards sustainability. The transition towards sustainability begins with individuals, and our ways of listening, talking with, and understanding each other. We believe that our group process allowed us to explore these fundamental aspects of sustainable development at a very personal level, preparing us to work in the collaborative ways required to participate in, and co-create, a large-scale societal shift towards sustainability.

Here, we frame our process of working together to create this thesis using the three underlying principles of complex systems as our guide: interdependency, self-sufficiency and diversity. We created our own three-person organization according to these principles, allowing us to experience the rewards, and the challenges, of working in this way. We leave with a commitment to design our future social systems following this path.

Interdependency

In`ter`de`pend`en`cy

n. 1. Mutual dependence; as, interdependency of interests.

Although challenging at times, this interdependency provided the platform for incorporating each of our strengths into the thesis project. Creative brainstorming sessions, feedback, helping each other along the way and the shared intention of ‘a value-based thesis’ provided support to the research and writing process. The process included light-hearted moments and less-light-hearted moments, and we learned of the power of trusting each other along the way.

Intense collaboration was our method of choice during the conducting of interviews, field visits, workshop design and delivery, and case study selection. Moreover, the development of the structure of this paper, and making sure it was clear and concise, was a process in which we all have been heavily involved. The compelling way of presenting our work to advisors and classmates was the result of pleasant hours of creativity, fine-tuning, and shared joy.

Self-sufficiency

Self`-suf`fi`cien`cy

n. 1. The quality or state of being self-sufficient.

While recognizing interdependency, each of us retained our independent thinking and unique perspective, allowing our individual strengths to shine through. Trust and proactivity have been the two key ingredients that have allowed us to develop ourselves during this time. We each took responsibility for parts of the research, following our passion, interest and commitment.

Karen explored the systems perspective and has a notebook full of drawings to show for it. She provided insight in connecting diverse viewpoints and ideas, while keeping the overview in mind.

Augusto explored the roots of backcasting to support a robust process for design and planning in complex systems. The communication of our work through workshops and presentations has been strongly enhanced by the facilitation skills of Augusto.

Freek delved into questioning and understanding the concept of cradle-to-cradle, sharing valuable insights along the way. He brought us to the core of our interpretation of the concept and laid the base for the integration of cradle-to-cradle in a systems perspective.

Diversity

Di`ver`si`ty

n. 1. A state of difference; dissimilitude; unlikeness.

*They will prove opposite; and not resting in a bare **diversity**, rise into a contrariety.*

- South.

2. Multiplicity of difference; multiformity; variety.

The diversity of our group - coming from three different continents and three different backgrounds - allowed each of us to expand our perspectives and challenge our own ways of thinking. Our diversity provided an incredible opportunity to explore the links, connections and differences between our ways of approaching sustainable development. This provided

a profound learning experience that we will carry with us on our personal journeys as sustainability leaders, each in our own unique and creative way.

Glossary

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

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

5-Level Framework: a generic 5 level framework (system, success, strategy, actions and tools) for planning in complex systems (Robèrt 2004).

Sustainability Principles: consensus-based scientific principles providing complete and systematic conditions for sustainability (Robèrt 2000).

Framework for Strategic Sustainable Development (FSSD): an application of the 5-level generic framework, using the Sustainability Principles and the strategy of backcasting, towards sustainable development (Robèrt 2004).

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-effective design: “working on the right things instead of making the wrong things less bad” (McDonough and Braungart 2002a). It ensures that the entire process of product design is aiming at producing “food” for either the biological or technical metabolisms (McDonough and Braungart 2002a).

Eco-efficiency: term based on the concept of “creating more goods and services with ever less use of resources, waste and pollution” (WBCSD 2000).

Biological Metabolism: all processes related to biological cycles needed to maintain life on the system (biosphere). In our case, the cycles of nature.

Technical Metabolism: the cycles of industry, including the harvesting of technical materials from natural places (McDonough and Braungart 2002a).

Downcycling: the recycling of a material into a material of lesser quality.

Upcycling: materials maintain their status as resources and accumulate intelligence over time (Braungart, McDonough and Bollinger 2007).

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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.

The specific systems under study when it comes to sustainable development are introduced with the Nested System Model presented in figure 1-1: individual within community / organization within society within the biosphere. All system levels are interconnected and interaction between the scales is such that change at one scale affects change at other scales (Holling 2004).

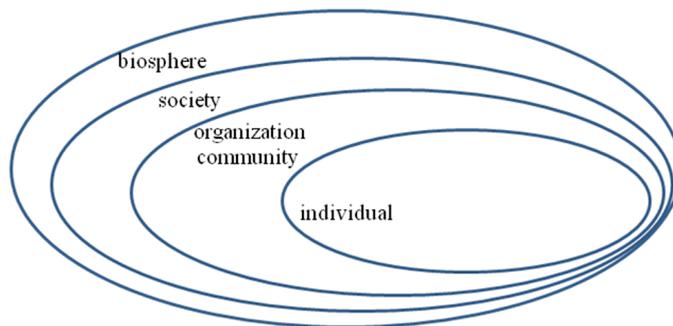


Fig. 1-1: Nested system model.

The process of sustainable development is an ideal of development efforts in this series of nested complex systems (Mitroff and Linstone 1993). Sustainability can be defined as a future state when the social and ecological systems are no longer systematically degraded, with sustainable

development as the process to reach this future state (Holmberg and Robèrt 2000). Once these systems are no longer being systematically destroyed, there is the potential for the restoration of socio-ecological systems beyond the minimum requirements for long-term survival.

More recent work has stressed the importance of highlighting the process nature of sustainable development (Holling 2004, Bagheri and Hjorth 2007). Holling has proposed the following definition: “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). 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). Therefore, this paper focuses on sustainable development as a social learning process, and refers to the Holling definition within that context.

Our understanding of the system is evolving, and it has become apparent that the development of human society is on an unsustainable course (e.g. Brundtland (1987), Daly (1996), Hawken et al. (1999), Stern (2007)). 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 manner, humans thrived in times of abundance and dwindled in times of scarcity. Ten thousand years ago, when anthropocentric agriculture and started to spread, the majority of the human population chose the course of modern civilization (Quinn 1992).

More and more, modern humans no longer experienced themselves as a part of nature, but as an external force destined to dominate and conquer it. People spoke of a battle with nature, forgetting that if the battle was won, humans would still 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 a perception of the world as a machine. Thus, the world-machine became the dominant metaphor of the modern era. Thus, this radical change was brought about by 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).

In the current economic paradigm, growth is largely based on the deterioration of social and environmental systems. Linear models of production, such as the Take-Make-Waste model, externalize costs onto those with the weakest voice: society's poor and future generations. According to Meadows et.al. (1992), "without significant reductions in material and energy flows [into nature], there will be in the coming decades an uncontrollable decline". 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 the potential for redesign of the systems is also being undermined (Robèrt et al. 2004). 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 more we study the major problems of our time, the more we come to realize that they cannot

be understood in isolation. These natural limits to growth need to be considered and understood in the development of new industrial processes. There are systematic problems that 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).

Fortunately, a sustainable society is still technically and economically possible, and is more desirable than a society that tries to solve its problems by constant expansion (Meadows et.al. 1992). The problem must be thoroughly understood in order to see the possibility of evolving a new lifestyle, 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 upon) 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 that physical flows from 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 based on a systems view of the world. 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 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 opportunities of future generations (Capra 1996).

1.2.1 Cradle-to-Cradle and the FSSD

Both cradle-to-cradle and the framework for strategic sustainable development (FSSD) are methodologies for planning and/or designing 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 the FSSD. In order to approach this goal, the following hypothesis is tested:

Backcasting using sustainability principles is supportive to the implementation of the cradle-to-cradle concept.

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

Main Research Question

How could cradle-to-cradle and FSSD, in principle, be combined to create an integrated approach to promote sustainable development?

Sub Research Question

What process could be used to implement such an integrated approach?

1.4 Scope and Limitations

The recommendations provided are as generic as possible, given the method of testing within a specific case study. However, it should be noted that the research context in the Netherlands is unique, and could limit the generality of the results. The main focus of this study deals with the strategic planning process, and does not prescribe specific actions or tools.

2 Methods

2.1 Chosen Approach

The focus of this research was defined through conversations with decision makers at 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 Dutch society. 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. The intent has been to frame cradle-to-cradle in a way that supports sustainable development at the societal scale.

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 the province of Limburg, a provincial government in the south of the Netherlands.

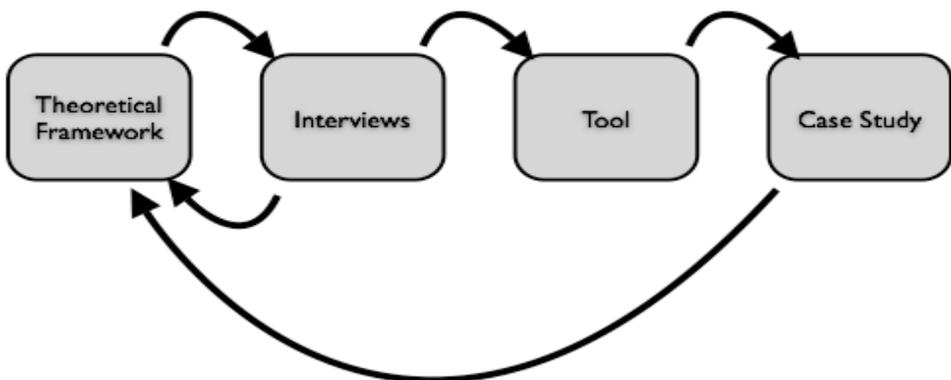


Fig 2-1: Iterative research approach

2.2 Research Phases

2.2.1 Exploratory Interviews

Interviews were conducted with practitioners engaged in various sectors of society and involved in the cradle-to-cradle networks in the Netherlands (full list of interviewees is included in 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. *strategic process guidelines*).
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:** Any tool that enables the process of strategically working towards success. (e.g. *strategic tools: monitoring and reporting on process; systems tools: monitoring and reporting on the system; and capacity tools: tools that help people learn*) (Robèrt et al. 2004, 28-50)

The analysis of concepts within this framework was based on literature review on both the FSSD and cradle-to-cradle, with a focus on connecting and comparing the two concepts. The methodology is based upon a similar analysis of Industrial Ecology (IE) 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 the FSSD and the cradle-to-cradle concept were analysed 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 Capacity Tool for Strategic Planning

This phase served to explore a strategic process 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, to explore and identify concepts to aid in a societal transition towards sustainability based on the cradle-to-cradle concept.

Province of Limburg

The tool 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.

Workshop

The workshop was designed with the following objectives:

- To explore how this process could strengthen cradle-to-cradle and sustainable development projects in the province of Limburg;
- To show how backcasting can be useful in strategic planning towards sustainability;
- To enable the participants to define principles to backcast with.

The workshop was four hours long, and included an introduction to the systems perspective of sustainable development, as well as an introduction to sustainability principles and the process of backcasting. Following this content, a dialogue took place about the characteristics of both sustainability principles and cradle-to-cradle principles in the context of strategic planning. The workshop closed with an exercise to explore the applicability of this process to specific projects.

Debrief and Feedback

Workshop participants filled out a feedback form at the end of the session. The form included three questions:

In what ways can backcasting using sustainability principles be valuable for the process of sustainable development in the Province of Limburg?

What advantages do you recognize for the Province of Limburg in sharing a vocabulary and thinking model around sustainability?

What are the insights that you have acquired during this afternoon?

A debrief session with Wouter Kersten from Enviu was held the day following the workshop to receive feedback on possible improvements in

both process and content. In addition, phone interviews with representatives from the province of Limburg took place two weeks following the workshop to further explore applicability and improvement to the process.

Limburg Representative 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

3 Results

3.1 Mapping out Key Concepts

3.1.1 The Framework for Strategic Sustainable Development

The Roots of the 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) have, based on scientific consensus, identified the following 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, 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 by perpetuating current trends. Given multiple possible futures, decision makers are looking for the most desirable rather than the most likely one (Robinson 1988).

The FSSD strategy focuses on the process of backcasting using sustainability principles, instead of focusing on the creation of a desired scenario. To accomplish this, the FSSD provides a set of sustainability principles to work as boundary conditions. As long as these principles are complied with, the scenario developed within these boundaries is inherently sustainable. Backcasting using 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 complementary 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. Concepts such as industrial ecology, biomimicry and cradle-to-cradle provide sets of simple design rules that allow us to learn from these characteristics of natural systems (Ehrenfeld 1997, Benyus 2002). 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 three tenets around which cradle-to-cradle is built are:

- Waste = Food
- Use current solar income
- Celebrate Diversity

(McDonough and Braungart, 2002a)

The cradle-to-cradle concept draws from the field of industrial ecology, where Ayres (1989) coined the term 'industrial metabolism' referring to the web of flows of energy and material in industrial processes. 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).

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 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).

3.1.3 Cradle-to-Cradle and FSSD Analysis within the Five Level Framework

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 FSSD, 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 the 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 FSSD 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 support strategic sustainable development?

System

Both the 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 3-1: Graphical representation of the three key tenets of cradle-to-cradle: waste = food is represented by the (t)echnical and (b)iological metabolisms, use current solar income, celebrate diversity.

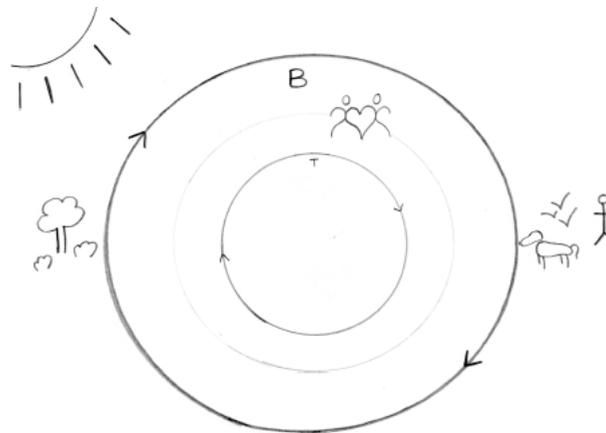


Figure 3-2: Systems view of the components of cradle-to-cradle. The biological metabolism goes in cycles of photosynthesis and respiration and is driven by energy from the sun. The representation of the technical metabolism within the biological metabolism highlights the interconnectedness of the two metabolisms; the technical metabolism is created by society.

Although the systems view and the concept of closed loops are shared, cradle-to-cradle and the 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 communicates the opportunities for positive effects on the external system, whereas the 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. The 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 FSSD is delineated by the four sustainability principles introduced in section 3.1.1.

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

And in that society...

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

The tenets of cradle-to-cradle, which define success for that concept, are:

- Waste = Food
- Use current solar income
- Celebrate Diversity

(McDonough and Braungart, 2002a)

This section explains the links between these definitions of success from a systems perspective.

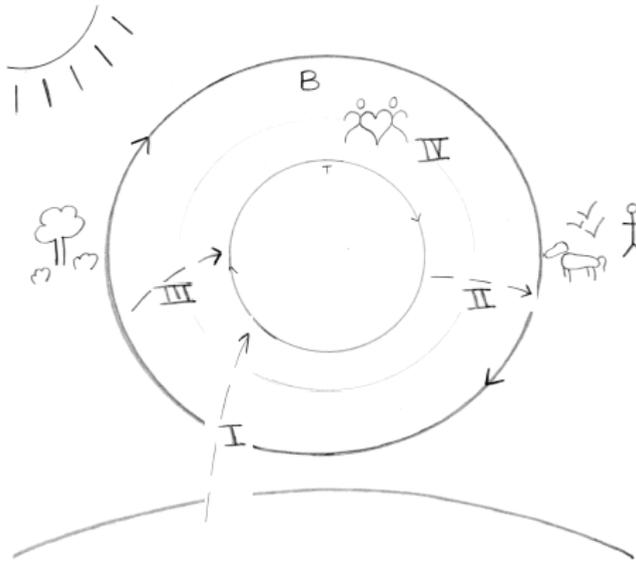


Figure 3-3: Systems view including technical and biological loops: society within the biosphere, powered by the sun. This figure also shows flows from the lithosphere and the biosphere to the technosphere, as well as from the technosphere to the biosphere. The roman numerals indicate the sustainability principle these flows are associated with; “waste = food” has the potential to lead to a reduced extraction flow in I, reduced degradation in III, and a reduced waste flow in II. “Use current solar income” has the potential to lead to a reduced flow in I. “Celebrate diversity” has the potential to lead to reduced violations in III and IV.

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 planning using backcasting, which means that they are framed in the negative in order to identify boundary conditions and 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 framed in the positive in order to serve as sources of inspiration and are not systematic neither 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.

The following table shows a summary of characteristics of both sets of principles, highlighting the distinctions between the two ways of communicating principles of success.

Table 3-1: Summary comparison between cradle-to-cradle principles and sustainability principles.

<i>Cradle-to-Cradle Principles</i>	<i>Sustainability Principles</i>
Metaphor	Robust
Creative	Systematic
Design	Planning

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 can be backcasting from scenarios of the future, based on this positive metaphor.

This metaphor can be useful as a source of inspiration, although it 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 for creation, 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 of cradle-to-cradle: “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 strategies, 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 for working towards eco-effectiveness focuses on product design using 5 steps, starting with four steps outlining actions that 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 (Braungart, McDonough and Bollinger 2007). This does not necessarily align with the strategy of backcasting from an overall sustainability perspective and systems approach, where investments in infrastructural projects designed for the collection of products have the

potential to be more strategic steps compared to material replacement investments for existing products. From a strategic sustainable development perspective, substitution with safe and natural materials is not a strategic step in itself, 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. It is stressed 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). They acknowledge that efficiency and effectiveness can be complementary strategies (Braungart et al. 2007), although 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 reveals the 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 a lot of potential in the integration of cradle-to-cradle and the FSSD strategies, as the creative design of specific solutions and approaches is a crucial component of the backcasting 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.

Synergetic Nature of Cradle-to-Cradle and the FSSD

The 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 designed for the incorporation of diverse tools and concepts that support the strategic goals. This provides an open and flexible approach that supports 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 paradigmatic and metaphoric and the last stage is descriptive and analytic. In order for a paradigm shift to occur, a deep change is needed in the first stage, not only a change in the second stage (Ehrenfeld 1997, Korhonen 2002). The FSSD has a structured planning and decision-making process to implement specific actions towards this new paradigm of cyclical relationships in a systematic way, and cradle-to-cradle has the potential to engage and communicate this new paradigm to many people.

3.2 Implementation

3.2.1 Current Reality of Cradle-to-Cradle Implementation

Research and 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 should be linked. In particular, the current focus on material replacement within existing products often leads to more energy intensive production methods. This has the potential of leading to a trade-off in terms of absolute physical impact of activities, depending on the energy source used (G. Korevaar, personal communication, 2008).

In order to achieve a sustainable relationship between society and ecological systems, 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 metabolisms 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 the societal infrastructure required for that transition.

Individual businesses generally have control only over a small portion of the material flow systems of which their products are 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 just beginning. In order to build this infrastructure, 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, and collaboration and systems thinking will be key to ensuring that they also move in the direction of societal sustainability.

3.2.2 Backcasting Using Sustainability Constraints and the Cradle-to-Cradle Concept

Complex systems require a specifically designed planning. The system of organization, within society, within the biosphere is an example of such a complex system. In the following section, the process of backcasting using principles for sustainability is explored.

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 aspects at Shell characterize the 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 enabled the exploration of possible futures that could happen, aside from 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 (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. (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 an 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 behaviour (Dreborg 1996), a shared intention is essential in organizations (Senge 1990, Collins 1994) or in a society (Boulding 1988).

For both organizations and society, 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 to 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 (2003) defines as a “second generation” form. 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-centred and lies on the hands of experts often puts as secondary matters the social and cultural structure of the system. The inclusion of 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) 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), 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 model an event in such a way that experience always confirm it, until a better model takes its place (Kuhn 1962; Checkland 1981). 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 child in high school, provided with some data, can give us a good prediction of the velocity of this object based on a Newtonian model.

Analogue 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 observes re-creates their 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 their 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). For instance social science, as opposed to natural science, 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).

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 bringing understanding of the overall system by identifying first-order principles to

support the creation of more customized and shared principles. In social sciences, Holmberg and Robèrt (2000) use basic human needs as a generic first-order principle from which social tailor-made principles could be analysed against. This first-order social principle is explicit as the fourth sustainability principle.

Backcasting using scientific first-order principles as constraints 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 it 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 designing scenarios and processes of a future state that is at least sustainable, it is important to acknowledge these boundaries in order to be able to create within them. This is the basis of what Robèrt et al. (Robèrt et al. 2004) call “creativity within constraints”. Being creative within constraints 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

The same way that knowing that you are not travelling to outer space does not define your next holiday trip, having the description of the system by sustainability principles does not define your strategy. Knowing where you are not going does not define your strategy, just frames it.

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. This second set of principles – principles for design – works as a guideline for the future state of the system designed by its stakeholders, a form of effective social engagement (Banathy 1998). This collective vision of shared principles sets up the creative tension that is needed for innovative 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 (1996) suggests that backcasting should include a view on the role of values. 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 support the definition of inspiring pictures of a future state.

This map gets more detailed as the journey toward the vision progresses, but initially details of possible future states are not determined, allowing for 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).

When aiming for sustainability, the planning phase of this strategic approach requires backcasting from a vision – or initially from design principles – defined by members of the system themselves through participatory consultation, while using sustainability principles as a constant systemic reference.

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).

Backcasting Using the Cradle-to-Cradle Concept

Cradle-to-cradle is the approach of designing systems 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 (2002a, 183), “it is important (...) that signals of intention be founded on healthy principles”, assuring that one problem is not being substituted for another. This approach is aligned with using principles for design and, when complemented with the use of sustainability principles, provides a robust planning process: backcasting from a vision of success. Figure 3-4 represents the generic steps for implementation through backcasting.

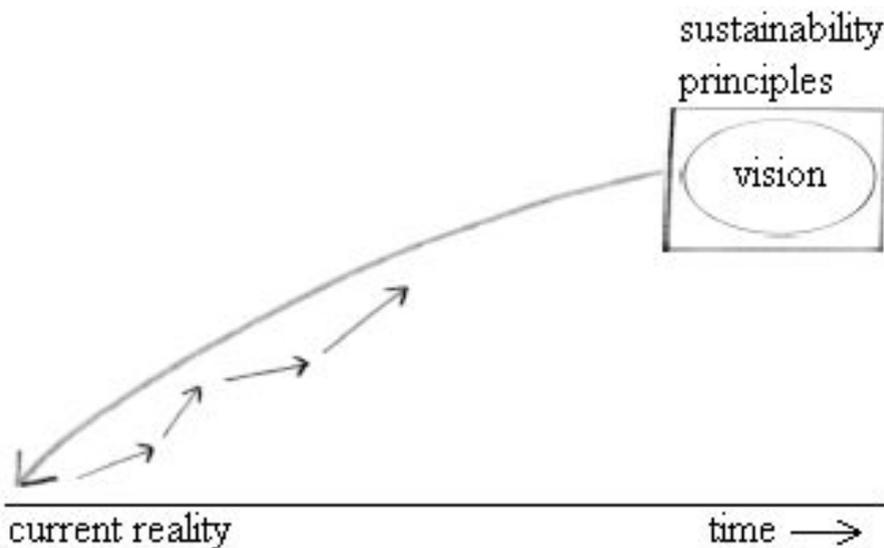


Figure 3-4 – Process of backcasting from a designed success state.

I) Designing principles of a future state.

The society's or organization's success aspects are identified in the first stage through identification of core purpose, core values and identification of existing strategic goals. 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 developed.

II) Analysis of current reality.

By looking at the current reality through the lens of the sustainability principles and the vision of success an analysis takes place of the gap between the state of success and the current reality.

III) Creating compelling measures.

The identified gaps serve as creative tension based on which actions and measures are brainstormed and identified that have the potential to positively contribute to a shift towards the vision.

IV) Setting priorities.

The compelling measures are prioritized through an analysis of its compliance with the boundary conditions. In order to prioritize, the following questions are asked:

- Is the measure a step in the right direction?
- Can the measure be a platform for further development towards the vision?
- Does the measure provide the organization an adequate return on investment?

V) Creating the strategic plan.

In order to, after prioritization, solidify the compelling measures a plan of implementation is created with the aim of institutionalizing the actions and measures. (Robèrt et al. 2004, 242-248)

3.2.3 Case Study

Current Reality of Cradle-to-Cradle Implementation in the Netherlands

The cradle-to-cradle concept is, compared to the rest of the world, very popular in the Netherlands. After the broadcasting of a very compelling documentary on the concept in November 2006, many initiatives have begun in order to implement the concept. Through interviews with decision-makers working with cradle-to-cradle, a gap was identified between understanding of the system and the identification of actions and tools. In particular, there is a lack of shared understanding of success and a 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 an uncertainty as to how to determine strategic steps to work towards cradle-to-cradle. There is a shared concern that unless clear strategies and concrete successes are achieved, this surge of enthusiasm around the cradle-to-cradle concept will remain a hype and fail to institutionalize real, and tangible, change towards sustainable development.

Current cradle-to-cradle implementation efforts lack a systems overview and strategic approach. Questions at the systems level to practitioners implementing cradle-to-cradle projects triggered responses that specifically related to their area of expertise. At the same time responsibilities for certain key aspects with respect to the systemic implementation were shifted to other parties. For example, one interviewee stated ‘I trust that someone else will take care of the energy problem’.

On the other hand, 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 (Thesingh, Levels, Kersten, Korevaar, personal communications, January 2008). Also, the networks are bringing together people from different sectors of society to interact in unconventional ways, with the shared intention of working towards sustainable development. The opportunity that arises from this shared enthusiasm for working towards sustainability based on the cradle-to-cradle concept is the possibility of having a constructive dialogue around the building of an infrastructure that supports the closing of loops. Several

players from all parts of the supply chain are involved and open to the exploration of possibilities to enable cradle-to-cradle production.

Current Reality of 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 (Thesingh, Levels, Albering, personal communications, 2008). These projects are in the early stages, and interviews showed that a strategic perspective would be beneficial when planning towards the objectives proposed.

The Province of Limburg is the organization responsible for the development of the most Southern province in the Netherlands. Within the Netherlands, the region of Limburg is the area where most activity takes place around cradle-to-cradle.

The province of Limburg is in the midst of a visioning and strategic planning process in order to transition the region towards a more sustainable community, inspired by the cradle-to-cradle concept. On March 28 2008, a multi-departmental brainstorm took place in which actions and measures have been suggested on the strategic, tactical and operational levels, 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 solid project planning. The participants have succeeded in having a productive brainstorm session and are facing the challenge of translating it into 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 to integrate sustainability in decision and policy making. 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, personal communication, 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. One 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.
- we 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 that reason facing the challenge of translating measurements 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 of 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."

The familiarity of people in the Netherlands – and specifically in Limburg - with the concept of cradle-to-cradle and the design principle of “waste = food” is of great value when mobilizing people to make their contribution in sustainable development. We found that the buy-in and engagement with cradle-to-cradle is broader and bigger than the support for sustainable development in general.

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. This was achieved by integrating the strengths of both the FSSD and cradle-to-cradle. The workshop was designed to provide space for dialogue around how strategic planning towards sustainability, based on cradle-to-cradle, could be applied in the Province of Limburg.

The workshop was designed around the acknowledgement that the system ‘Province of Limburg’ is a complex system. A comparison took place between two sets of principles, one derived from the cradle-to-cradle concept and the other from principles for sustainability. After that an exploration of the process of backcasting took place and how it relates to both sets of principles. In conclusion, application of the process in one of the real local challenges was practiced.

As a first step it was explored that planning in complex systems demands for a process specifically designed for that end, and the approach of backcasting using principles was selected as the most appropriate. The province itself was already using the cradle-to-cradle principles and other guidelines as sources of inspiration. During the workshop the principles for sustainability were introduced, as well as the set of criteria that they were designed to meet, namely that they are:

- Concrete
- Non-overlapping
- Necessary
- Science-based
- Generic
- Sufficient

Following this, a dialogue took place around the question of how both the principles for sustainability and the cradle-to-cradle principles can be of

value in supporting the strategic planning in the context of sustainable development at the province of Limburg.

Table 3-2 shows the words used by participants of the workshop in Limburg to describe characteristics of both sets of success principles, relevant to the process of backcasting. The participants value the cradle-to-cradle principles as a good way to communicate and inspire people. Also, initial reactions to the sustainability principles were that they could be applied for planning purposes and be of assistance in determining if and in what way brainstormed ideas are to be implemented.

Participants were given the space to apply the prioritization questions to their own projects and are now in the process of seeing how to incorporate the backcasting approach in their own decision-making process. The province is in the process of writing down their long-term goals and identifying and prioritizing the different steps that can be taken to reach their goals. 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 it provides a clear mental model that can lead decision makers in the development of your policies.

The process of the workshop itself provided key insights into the application of the proposed process in practice. During the workshop, researchers noticed anxiety and impatience of some participants during the first steps of coming to the systems understanding.

Table 3-2: Characteristics identified by workshop participants.

<i>Cradle-to-Cradle Principles</i>	<i>Sustainability Principles</i>
Start a transition	Academic
One answer	Scientific
Vision	Concrete
Ambitious	Smell the numbers
Challenging	Quantitative
Long-term	
Solutions	
Appealing	
Concise	
Simple words	
Understanding	

4 Discussion

Results support the hypothesis that backcasting using sustainability principles is supportive to the implementation of the cradle-to-cradle concept, especially in terms of contributing to a systematic implementation of cradle-to-cradle with respect to sustainability.

4.1 Principles and Process

When looking into the question of how cradle-to-cradle and FSSD could be combined to create an integrated approach to promote sustainable development it was decided to focus on an innovation at the success level; principles for a sustainable society. 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 information collected through 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 that trigger creativity. The FSSD is most effectively implemented when combined 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 validity of making a distinction between decision-making and design principles was supported by the outcomes of the workshop. This happened through conversations exploring the potential uses for and characteristics of the sets of principles used in 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 value of communicating these principles in order to trigger the creation of a compelling 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’, highlighting the strength in using these principles for robust planning and also showing their weakness from a design perspective. In terms of process insights, participants 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 as a bridge between inspiring metaphorical concepts and strategic implementation. This mirrors the two stages for a paradigm shift proposed by Korhonen (2004), in which the first stage in understanding of a new paradigm are metaphor based, and the final stage is based upon specific measures, indicators and implementation (Korhonen 2004). The research is significant as an example of how inspiring principles and concepts, such as the cradle-to-cradle concept, can be integrated within the approach of backcasting using sustainability principles, resulting in an inspiring, robust and strategic approach to sustainable development.

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 when working on the implementation of the cradle-to-cradle concept. 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.

The approach and process used was based on the specific needs of the Netherlands for implementation of the cradle-to-cradle and assumes that the reader is knowledgeable of the concept and enthusiastic on using it as a platform to achieve sustainable development. 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 results show findings generic enough to be applied by any organization that wants to design using the cradle-to-cradle concept.

4.2 Workshop Implementation Insights – The Social Learning Process

When considering what process could be used to implement an integrated approach of cradle-to-cradle and FSSD it was 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. 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.

This insight, although perceived in the Netherlands, is a common trend in the field and has been addressed by scholars and practitioners by including more stakeholder participation on the process of implementation, as shown in section 3.2.

4.3 Societal Transition towards Sustainability

In the Netherlands, cradle-to-cradle is taking wings. The shared language of cradle-to-cradle, with its focus on the creation of technical metabolisms, provides the unique potential to trigger conversations around the enabling of a societal infrastructure that supports organizations in their transition towards participation in cyclical supply chains. Currently, efforts that aim to contribute to cyclical, instead of linear, production/consumption methods are difficult to implement. Society is currently designed in a way that supports take-make-waste behaviour rather than a society that supports cyclical supply chains. A shared effort to make 'waste = food' opens doors for collaboration for cradle-to-cradle enabling. Cradle-to-cradle gives

direction to the needed societal transition towards cyclical relationships and its principles for design provide an appealing invitation for this innovation. Creating a societal infrastructure that supports the closing of loops is inherently part of the cradle-to-cradle definition of success. For the individual organization working with the FSSD, contribution to the creation of closed loops is not a requirement in itself. True innovation at a societal level can therefore be expected more from implementation of cradle-to-cradle than from implementation of the FSSD.

Although this work explores the concept of cradle-to-cradle as this shared language and innovation-enabler, other concepts and design principles could be explored as a substitute for them, as long as they have the synergistic characteristics explored in 3.1.3.

5 Conclusion

Both design and decision-making are key components within the process of backcasting using 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 complementary sets of principles and approaches to support a strategic transition towards sustainability.

Sustainability principles, or boundary conditions, are best applied within a process that is 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. In the case of sustainable development, sustainability principles have been specifically designed as a base for robust decision making. 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.

Based on this study and the demand for both academic and practical exploration of the concepts explored, two main suggestions for future research are: generate a customized process that integrates both the design and decision-making phases of backcasting using sustainability principles to implement the cradle-to-cradle concept; map the societal infrastructure needs of either the Netherlands or another system through a multi-stakeholder dialogue and explore how the process of design and decision-making can be applied. 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.

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Appendices

Appendix A: List of Interviewees Jan 28 – Feb 2

Name	Organization and Location & Function
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 Hetteema	Interface Europe Scherpenzeel Large business
Gijsbert Korevaar	TU 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 sizes 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

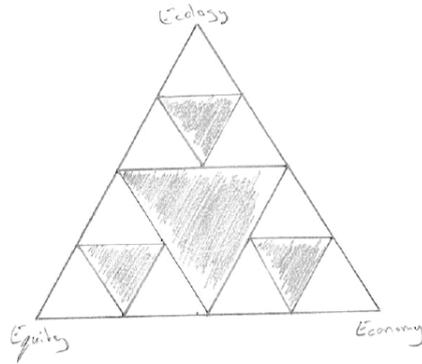
Harry Rutten

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. 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).

Fractal Triangle Questions

(McDonough and Braungart 2002b)

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 pure capitalism

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

Economy/Equity – profitability and fairness

Are employees producing a promising product earning a living wage?

Equity/Economy – fairness 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 / Efficiency

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 C

Five Steps to Eco-Effectiveness

(McDonough and Braungart 2002a)

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 product is made, and how they are combined, is the goal. ... Nevertheless, there 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 fulfil 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