

The 22nd CIRP conference on Life Cycle Engineering

## Cradle to Cradle: Effective Vision vs. Efficient Practice?

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### Abstract

Cradle to Cradle is a development paradigm with a focus on eco-effectiveness; improving the 'positive footprint' in contrast to the more conventional eco-efficient approaches; reducing the 'negative footprint'. Industry is supported in their Cradle to Cradle efforts by an elaborate five level certification framework. The accredited institutes necessary for certification focus in practice mainly on material health, underexposing other aspects. The aim of this paper is to explain why the eco-effective Cradle to Cradle vision in practice results in a mere eco-efficient approach by discussing several conflicts between theory and practice. This is illustrated with a case study resulting in a development method for Cradle to Cradle compliant packaging.

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Peer-review under responsibility of the scientific committee of The 22nd CIRP conference on Life Cycle Engineering

*Keywords:* eco-effectiveness; Cradle to Cradle; packaging development

### 1. Introduction

Since the introduction of the Cradle to Cradle<sup>®</sup> <sup>1</sup> philosophy, publications often dealt with the success stories [1]. Companies mainly communicated their Cradle to Cradle certified products through press releases [2]. However research on the actually application of Cradle to Cradle as design paradigm is rather limited. Especially research on evaluating the applied business models versus the philosophy and the consequences for product development seems to be lacking.

To discuss consequences of the current practice for product development, this paper starts with explaining the principles of the Cradle to Cradle philosophy. Followed by a description of a packaging development case study to illustrate the application in industry. From this case study it becomes clear in section 5 that in practice the good intentions are actually limiting the necessary innovations to achieve Cradle to Cradle products. This paper concludes with a proposal for

reconsidering the current business models to improve efficiency of developing more sustainable and Cradle to Cradle compliant products.

### 2. Cradle to Cradle

Concerns for the environmental impact and depletion of resources as a result of unlimited economic growth [3], have stimulated engineers, for many years, to reduce the impact of product lifecycles. Guidelines for product development were often restrictive, with a negative touch, resulting in the feeling of limiting economic and industrial growth. As a reaction to these restrictions Braungart and McDonough introduced their vision on effectiveness that uses positive growth as driving force behind the transition towards a more sustainable world. In 2002 they published their book *Cradle to Cradle: Remaking The Way We Make Things* [4]. The Cradle to Cradle philosophy focuses on an ideological transition from 'less bad' to 'more good'. The well-known conventional eco-efficient approaches strive for reducing the ecological footprint to minimize the damage inflicted on the world. Instead of this negative message, Cradle to Cradle focuses on eco-effectiveness by stimulating to do the right things in order to improve our positive footprint. For this transition a continuous

<sup>1</sup> Cradle to Cradle<sup>®</sup> is a trademark of McDonough Braungart Design Chemistry, LLC.

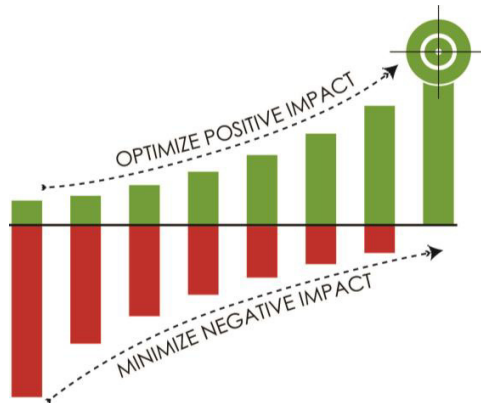


Fig. 1. Eco-effective vs. eco-efficient (edited from [5]).

improvement in product development, industry and economy will be necessary, see also figure 1 [5]. Instead of limiting economic and technologic growth, Cradle to Cradle actually uses this growth to drive the necessary innovations for these transitions. The positive message of Cradle to Cradle attracts a lot of enthusiastic reactions from industry and government in the Netherlands. Examples are illustrated in a recently published impact study [6] on Cradle to Cradle certification by the Cradle to Cradle Products Innovation Institute. Several important business, social and environmental benefits were recorded from the experience of ten early Cradle to Cradle adopting companies.

### 2.1. Three main principles

In order to achieve a sustainable world based on the Cradle to Cradle philosophy, products should be beneficial in health, environmental and economic terms. The Cradle to Cradle design paradigm consists of these three main principles [7];

Waste equals food, based on the analogy of metabolism cycles, all materials should be seen as nutrients for other product lifecycles either in a biological metabolism or technical metabolism (see also section 2.2).

Use current solar income for sustainable energy. In order to create, operate and dissolve Cradle to Cradle products only sustainable energy sources should be applied. Within the design paradigm it is assumed that these renewable energy sources are widely and abundantly available without practical restrictions.

And finally celebrate diversity. To improve a system's resilience, diversity is necessary. Focusing on one criterion could cause instability and imbalance in a wider context [8]. Biodiversity, cultural and conceptual diversity improve relationships, creativity and innovation.

### 2.2. Two material type metabolic cycles

Within the Cradle to Cradle framework, two distinct metabolisms are acknowledged: the biological metabolism and the technical metabolism. Within the biological cycle, typical consumption products can be identified; products of which the materials are returned to the environment by diffuse pathways,

like water or air emissions, even during the use phase. These products should be made from renewable sources and act as (biological) nutrients in the production of new resources.

In the technical cycle mainly service products are identified without material loss during their use phase. Non-renewable materials should flow into industrial systems to act as nutrients in manufacturing new products. Within the Cradle to Cradle philosophy mere recycling is not enough, in fact the materials should be of equal or preferably of higher quality, for which the term upcycling [9] is introduced.

A third possibility to keep the materials in a semi-closed loop is the cascade model where materials are kept within a technical cycle for a certain amount of iterations, while down-cycling in properties before flowing back into the biological cycle. Paper recycling is a typical example of the cascade model within the Cradle to Cradle design paradigm.

### 2.3. Certification

An important difference between the Cradle to Cradle design paradigm and many other approaches to achieve a sustainable world is the elaborate and well-developed certification framework. Cradle to Cradle is not only a philosophy on sustainability, but it has its own framework for certifying compliant products. This framework is mainly intended to support companies creating Cradle to Cradle products. A certification can be considered a reward for the achieved results.

For certification, products are evaluated against criteria from five distinct categories; material health, material reutilization, renewable energy, water stewardship and social fairness. Important within the category material health is the applied ABC-X assessment methodology, classifying materials based on chemical risk and recyclability in (theoretical) biological and technical cycles. Resulting scores include A, B, C, X or Grey (unknown) and determine to a large extent the actual certification level. Overall, the certification framework is not merely a pass/fail model, instead it incorporates the concept of continuous improvement. The level of product certification depends on the scoring on the previous mentioned criteria categories, resulting in a basic level to start with, up to the platinum level for complete Cradle to Cradle compliant products.

The certification framework is designed to be applicable to materials, sub-assemblies and finished products. This scope is not limited to specific industries or product types [7].

As a result of the certification process companies can obtain a certification mark for their Cradle to Cradle product. This mark, expressing the certification level, can be displayed on the product. Except for the basic level mark, for which this is not allowed.

## 3. Cradle to Cradle business

In theory Cradle to Cradle appears to be an effective vision with its positive message of doing more good instead of doing less bad. From our experiences and numerous dedicated events, the Cradle to Cradle philosophy with positive growth as driving force to innovate and expand was well-received in

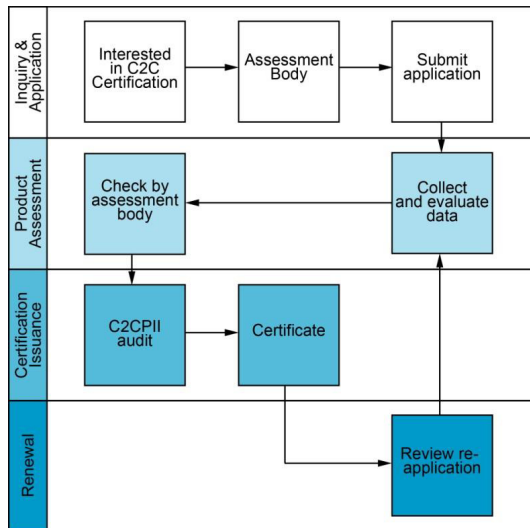


Fig. 2. Process of Cradle to Cradle certification [10].

many manufacturing companies and supported by the Dutch Government [1]. Feasible economic models appeared for applying the Cradle to Cradle philosophy commercially. This was enabled by companies willing to invest in the development of Cradle to Cradle products requesting certification as a marketable reward for their efforts.

This resulted in at least three institutes important for the Cradle to Cradle certification. Braungart and McDonough have a leading role in the consultancy firms Environmental Protection Encouragement Agency (EPEA) and McDonough Braungart Design Chemistry (MBDC) to

support companies in their effort to develop Cradle to Cradle products. Obviously both EPEA and MBDC were also the first official accredited assessment institutes. For the necessary certification process itself, the 'Cradle to Cradle Products Innovation Institute' (C2CPII) was founded by Braungart and McDonough. While the C2CPII audits the product assessments by MBDC and EPEA, the Cradle to Cradle Certification Standards Board, which includes senior scientists from EPEA and other certified assessment bodies, is responsible for reviewing and approving revisions of the certification process.

### 3.1. Assessment process in practice

A company developing a Cradle to Cradle compliant product has to perform a product review to check if the necessary criteria have been met. Together with the important mutual nondisclosure agreement (discussed in section 5) the necessary documentation is sent to one of the assessment institutes. Although in practice that institute is often already consulted to assist in completing the necessary forms correctly, see figure 2.

The applying company has to acquire, assisted by the assessment institute, all the necessary data for the assessment in the five mentioned certification categories, including an assessment of the composition of the materials used during production as well as the production process itself. The

material assessment is completed according to the ABC-X-classification as mentioned in section 2.3. The resulting report by the assessment institute is sent to the C2CPII for evaluation and certification.

However, C2CPII principally only accepts material and process evaluations submitted by an accredited Cradle to Cradle assessment institute, like MBDC and EPEA. Certification is valid for two years and must be biennially renewed. And whenever changes in materials or processes have occurred a new material assessment and process evaluation by the accredited assessment institute is necessary.

## 4. Case study from Industry on packaging development

In order to apply the Cradle to Cradle design paradigm and experience the associated certification process firsthand, a case study in industry was conducted. The assignment was twofold, first to develop an appropriate method for the development of Cradle to Cradle compliant packaging and secondly to apply this method for the development of a specific packaging concept. This included illustrating the workability and forthcoming issues of the resulting method in a specific packaging development project. Although not unique in the industry, at Van Houtum on one hand the need for Cradle to Cradle packaging became a driving force for development. On the other hand, current Cradle to Cradle theory and packaging development is not structured for innovative Cradle to Cradle packaging development. This methodic approach has been developed from the ground up, based on current theory on Cradle to Cradle and packaging development.

This case study was executed at Van Houtum, a paper mill in the south of the Netherlands. For several years, Van Houtum has been a leader in sustainability and the implementation of Cradle to Cradle in hygienic products for washrooms. Under the brand of Satino Black the company already has several Cradle to Cradle certified products in its portfolio. For this brand a packaging concept for toilet paper aimed at the cash and carry market was developed together with Van Houtum. The case study was executed over a period of nine months and included close contact with experts from EPEA and many different material suppliers.

### 4.1. Methodology for packaging development

The Cradle to Cradle packaging development method is derived from relevant aspects in both Cradle to Cradle and packaging development [11-13]. It is intended to be used within companies for which packaging development is not core business, but are nevertheless committed to develop Cradle to Cradle packaging. The method is descriptive; using different steps and actions to develop Cradle to Cradle packaging. It consists of four distinct sections (Definition, Conceptualization, Detailing and Completion), separated by interim meetings acting as decision moments, giving the method a stage-gate approach. In figure 3, this division is visualized by the white diamonds between sections. Significant in these sections is the location of Cradle to Cradle

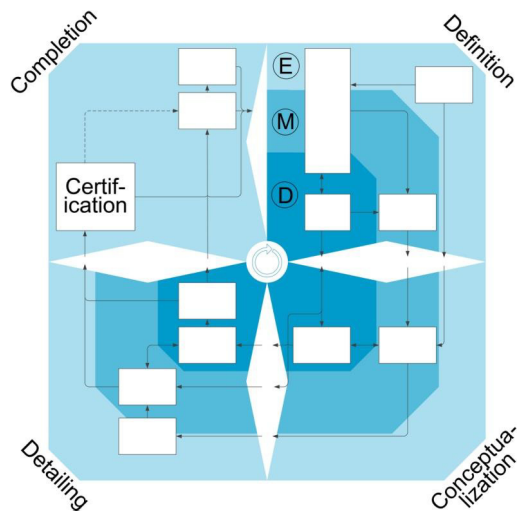


Fig. 3. Graphic representation of method (subtext has been omitted on purpose, full version is available from authors).

certification in the completion section, where all previous developments should result in the market implementation of the packaging concept. Cradle to Cradle certification is considered essential in this section. Therefore, the location of this development step is explicitly mentioned in the method.

A distinct feature of the method is the division into three layers, all with a different focus on the development steps: a Development Layer, a Material Selection Layer and an

External Layer (D, M and E in figure 3). From a Cradle to Cradle standpoint, the separation of the Material Selection Layer is essential. Due to the great importance of material contents in the Cradle to Cradle assessment and certification process, all material-related developments are concentrated in the material selection layer. With this structure it is possible to allow external parties to take care of the material-related developments. It enables companies with a non-packaging core business to develop Cradle to Cradle packaging.

#### 4.2. Developing Cradle to Cradle packaging

To illustrate the method for Cradle to Cradle packaging development, an appropriate packaging concept was developed. The subject of the project was initiated by Van Houtum's aspiration to enter the cash & carry market and to research Cradle to Cradle packaging, as mentioned earlier. The case study assignment was: *Develop a Cradle to Cradle suited packaging draft for Satino Black toilet paper, for the cash & carry market*. Aim of the project is the complete development of a Cradle to Cradle packaging draft, from preliminary research to market implementation, guided by the method described in section 4.1. Due to the importance of material health within Cradle to Cradle, the material research of the project was executed elaborately and with utmost attention.

During the development of the packaging concept, several specific practical issues surfaced, as in most development projects. However, in this projects these issues were striking because of the implications and limitations coming from

Cradle to Cradle (both theory and practice). An example is the incorporation of a type of borate derivate, essential in the starch glue used to produce corrugated board. During the process, this material was classified as a possible toxin. However, translating this claim into a measurable ABC-X score was only possible to be done by a Cradle to Cradle material assessment body, like EPEA or MBDC.

Similar issues have come up regarding adhesives and printing inks. Due to both unknown material content and unknown recyclability score, it is virtually impossible to search for Cradle to Cradle compliant inks without the assistance of a material assessment body. Also, in cases where recycled materials are considered (corrugated board, for instance), the suitability for the material to be used in a Cradle to Cradle product can only be determined by analytical testing and interpretation. Once again, impossible for a company or designer aiming for a Cradle to Cradle packaging concept to execute on its own. As a consequence, developing Cradle to Cradle (packaging) products aimed at being eco-effective results in a merely efficient approach, due to the mentioned issues.

#### 4.3. Resulting Cradle to Cradle packaging concept

Finally the developed packaging draft consists of a corrugated board box, closed with a lid out of PaperFoam<sup>®2</sup>. Also, the developed concept does not contain any adhesives for the construction and closing of the box. This unique innovation makes the concept well-suited for a post-use scenario in the waste paper system, with very limited loss of material quality (only non-recyclable inks and fillers). Even though this innovation is in-line with and inspired by the Cradle to Cradle philosophy, the actual design solution was developed independent of the Cradle to Cradle design paradigm. On the contrary, it is implemented in the packaging concept thanks to the creativity and innovations driven by Van Houtum and the packaging designer in this project.

The developed variant of the concept can be considered to be 'top-level', even surpassing Cradle to Cradle compliancy. However, for practical application, this draft could be easily adjusted. Practical constrains are likely to come from industry to increase the technical feasibility. And might include demands for specific automated packaging lines or improved strength during distribution and handling. By default, this adaptability has been taken into account in de design and development of the packaging, to enable continuous improvement of the concept to face developments in the future. By incorporating this adaptability, the design can be considered to be effective. But once again, this is not explicitly driven from the Cradle to Cradle design paradigm.

#### 5. Reflection: Theory vs. Practice

From the described case study in the previous section several striking discrepancies between the (close to utopian) Cradle to Cradle theory, assessment and certification practice

<sup>2</sup> PaperFoam<sup>®</sup> is a trademark of PaperFoam B.V.

are observed. This reflection on the application of the Cradle to Cradle design paradigm in practice is based on both a bird's-eye view and direct involvement with EPEA in the specific case study. First of all, the practical application of Cradle to Cradle philosophy shows that the material health is by far the most important, with the category material reutilization a distant second. The remaining aspects of Cradle to Cradle certification (water stewardship, renewable energy and social fairness) are implemented and assessed far less extensively. In most cases, declarations from the manufacturers will suffice for these issues. Resulting in a risk of developing products which are solely focused on "waste equals food" (in an eco-efficient manner) when the main material is considered, and comply to the other principles of the theory to a lesser extent.

#### 5.1. Position of EPEA in certification process

Another striking issue is the position of EPEA. Obviously, the company's business case is its near monopoly on Cradle to Cradle material assessment. MBDC together with EPEA are the primary institutes of which material assessments are accepted for Cradle to Cradle certification. Process assessments can be executed by other accredited institutes, but the material assessment will only be approved by C2CPII when signed and delivered by EPEA or MBDC and a selected few other institutes. Therefore, the material analysis as executed in the described case study is far from typical, since EPEA was only partly involved.

#### 5.2. Effect of NDAs on Cradle to Cradle innovation

The position of EPEA also has implications for how developments are being coped with. For the sake of protection of knowledge, most (relevant) Cradle to Cradle-related developments are secured in a mutual non-disclosure agreements (NDA) between EPEA and the developing company. In many cases this NDA is demanded by the applicant and agreed upon by EPEA. Although understandable from a commercial point of view this results in a striking lack of open innovation. After all, with a NDA in effect, EPEA cannot communicate on suppliers of the company with whom the NDA has been settled, let alone the specific (material-related) innovations. New developments, which could very well benefit from other Cradle to Cradle developments, are delayed or even cancelled. This results in Cradle to Cradle lacking in being an actual innovation driver, but merely a guide. Obviously, this is a missed opportunity for the sake of open innovation. The theory aims at (eco-)effectiveness, for which open innovation and interdisciplinary cooperation is an implicit requirement. Not facilitating (or even counteracting) this results in an eco-efficient practice.

#### 5.3. Unclear ABC-X categorization

The method applied for material assessments as mentioned in section 3, is an important part of the business case of EPEA. First, material specifications are acquired from a supplier. These substances are compared to EPEA's material databases.

The result of this comparison is the ABC-X categorization. The material databases used by EPEA are publicly available, as is the general guideline for material assessments [14]. However, the practical translation from guideline and database into a specific ABC-X score is not publicly available. This gives the impression that the actual categorization also depends on the interpretation by the accredited institute. The risk evaluation of a (harmful) substance in that particular material application results in the earlier mentioned ABC-X score, crucial for certification. This lack of transparency makes it impossible for other (and) independent institutes to reproduce (or check) the ABC-X categorization. For applicants this leads to a higher degree of uncertainty regarding the result of the material assessment. Both the final result and the substantiation of the consideration of the categorization are communicated.

#### 5.4. Optimization versus innovation

By far, most of the developments guided by EPEA are optimizations of current products [2]. This was also evident from the executed case study and can be noted from earlier publications [15] as well. It appears that the system of Cradle to Cradle is not very well-equipped to act as an innovation driver for the development of completely new products. This might be explained by the background of assessment institutes like EPEA and MBDC. They both employ mostly early adopters from the environmental, biological and chemical sciences. They are specialist in material analysis and the known harmful impacts on human and environmental health. EPEA and MBDC are not product or packaging development firms, with very limited amounts of employed product developers. This results in the institutes' tendency of conforming to the material assessments and internal procedures instead of evaluating the products from a true innovative Cradle to Cradle point of view.

Currently, a knowledge gap amongst product developers aiming for Cradle to Cradle inspired or certified products leads to the previous mentioned lack of innovation. The executed case study was not focused on targeting this gap.

#### 5.5. Lack of attention on energy consumption

In the assessment procedure, some issues are striking due to their absence. First, there is a lack of focus on the use phase of products. Although in line with the Cradle to Cradle theory, during certification only the beginning (production) and end of the cycle (post-use) are considered. Even though all steps in between can be of critical importance. The only way in which the use phase is involved, is the recommendation to communicate on the 'Cradle to Cradleness' of a product. This message should result in a post-use phase the way it was intended by the manufacturer of the product.

Besides the limited attention on the use phase, energy use in general can be considered a weakness of the Cradle to Cradle philosophy. In practice the majority of environmental problems of the more common products is related to energy consumption. Either during production, use and even the disposal phase. Keeping materials in continuous loops within

one of the cycles also requires energy for processing. In theory there is abundant solar energy received on the earth to drive our economy, giving rise to the idea that only renewable energy should be utilized. However this energy is not distributed evenly nor always easily accessible. The transformation from solar energy into useful energy (useful for industrial and economic processes) often requires either sophisticated materials for a feasible efficiency or large area's for a feasible capacity. Since Cradle to Cradle focuses mainly on materials, a thorough assessment of the energy flows is not the main target. Possibly the more familiar techniques like lifecycle assessment could complement the Cradle to Cradle philosophy in quantifying the energy impact.

## 6. Conclusion & Outlook

By applying the Cradle to Cradle philosophy to the development of a compliant packaging draft, quite some discrepancies between the theory and practice were exposed, as described in section 5. Some of these issues can be attributed to the novelty of the paradigm. However, two issues are considered to be critical, which are not merely related to the paradigm's novelty. The first regards the position of EPEA and other assessment bodies. These institutes should be focusing on setting up partnerships between companies that are working on Cradle to Cradle developments. This would initiate and stimulate necessary innovations. Related to this, also partnerships and processes could be certified in order to be beneficial for all stakeholder involved in certain Cradle to Cradle developments, instead of only the tier one, being the applying company. Even though this broadening of the certification framework is not researched, it might be a useful addition to the value proposition of Cradle to Cradle certification.

The other issue is the day-to-day practice of Cradle to Cradle. The background of the assessment bodies (being mainly materials experts), a focus on products (materials) optimizations instead of innovations and strict use of NDAs makes Cradle to Cradle in practice being merely a guide, instead of the innovation driver it could be.

These and other mentioned issues will have a high impact on the future of the current Cradle to Cradle paradigm. The way in which Cradle to Cradle is marketed currently will probably lead to a shift in its popularity. This is mainly due to the lack of an innovation driver and open development. Therefore, both institutes and companies involved in Cradle to Cradle developments should consider to embrace open-source innovation. Companies should be encouraged to develop together and communicate about collaboration. The current practice, with the suffocating NDA's limits proper (open) development. EPEA (and other accredited Cradle to Cradle assessment institutes) should shift their focus more towards acting as a knowledge platform and intermediates between different product developers and manufacturers. Then it will be much easier for companies interested in Cradle to Cradle developments to meet, interact and cooperate.

Cradle to Cradle philosophy is a solid and holistic theory on sustainable circular development, aiming for eco-effectiveness. It inspires companies and product developers to

search for innovative solutions to achieve a more sustainable world. However, this study shows the discrepancies between the theory and day-to-day practice of applying Cradle to Cradle in packaging development and more specific: the whole system and program of certification. This results in a practice which lacks true eco-effectiveness but could be more efficient.

Cradle to Cradle is eco-effective as a holistic theory and aims for innovation. But due to limitations from different sources, Cradle to Cradle in practice often turns out to be merely efficient.

## Acknowledgements

The authors thank Van Houtum B.V. for providing the opportunity for this research and EPEA for answering many questions during the case study. Many thanks also to suppliers in Van Houtum's packaging chain, including Smurfit Kappa Van Dam, PaperFoam B.V. and VPK Packaging.

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