Cradle to Cradle in a nutshell

C2C summary and design tools

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1.1 **Cradle to Cradle;** Remaking the way we make things

A design revolution. *This page is an excerpt of the MBDC website*

The industrial framework that dominates our lives now is fairly primitive. It is conceived around a one-way manufacturing flow—what is known as a "cradle to grave" lifecycle. This cradle to grave flow relies on brute force (including fossil fuels and large amounts of powerful chemicals). It seeks universal design solutions ("one size fits all"), overwhelming and ignoring natural and cultural diversity. And it produces massive amounts of waste—something that in nature does not even exist.

Consider looking at the industrial revolution of the 19th century and its aftermath as a kind of retroactive design assignment, focusing on some of its unintended, questionable effects. The assignment might sound like this: Design a system of production that

- Puts billions of pounds of toxic material into the air, water, and soil every year
- Produces some materials so dangerous they will require constant vigilance by future generations
- Results in gigantic amounts of waste
- Puts valuable materials in holes all over the planet, where they can never be retrieved
- Requires thousands of complex regulations to keep people and natural systems from being poisoned too quickly
- Measures productivity by how few people are working
- Creates prosperity by digging up or cutting down natural resources and then burying or burning them
- Erodes the diversity of species and cultural practices

Does this seem like a good design assignment?

Even though none of these things happened intentionally, we find this "design assignment" to be a limited and depressing one for industries to perpetuate—and it is obviously resulting in a much less enjoyable world.

A New Design Assignment

We are proposing a new design assignment where people and industries set out to create the following:

- Buildings that, like trees, are net energy exporters, produce more energy than they consume, accrue and store solar energy, and purify their own waste water and release it slowly in a purer form.
- Factory effluent water that is cleaner than the influent.
- Products that, when their useful life is over, do not become useless waste, but can be tossed onto the ground to decompose and become food for plants and animals, rebuilding soil; or, alternately, return to industrial cycles to supply high quality raw materials for new products.
- Billions, even trillions of dollars worth of materials accrued for human and natural purposes each year.
- A world of abundance, not one of limits, pollution, and waste.

Welcome to the Next Industrial Revolution.

Source: http://www.mbdc.com/c2c_nir.htm and Cradle to Cralde [MBDC, 2002]

1.2 **The cradle to cradle book** in a nutshell:

Rather than pollute and deplete the world, we can help it prosper trough consuming. We need two cycles of materials: a **technical cycle**, metabolising **technical nutrients** (inorganic materials) and a **biological cycle**, metabolising **biological nutrients** (biodegradable materials). The materials meet in products, and after the product's useful life is over, the materials are retrieved and returned to their cycles. This is different from recycling, where materials degrade in the process. If we **design for disassembly**, we can retrieve the **nutrients** (rather than waste) because there are no **'monstrous hybrids'**, comprising either of technical and biological nutrients that can not be separated, or of valuable minerals trapped in low quality bulk.

Better than eternally reusing materials at the same quality, we can improve the quality of materials trough use. In stead of **downcycling**, we **upcycle**; making used materials more valuable.

Alongside **products of consumption**, designed for safe and complete return to the cycles, we will have **products of service**, used by the customer, but owned by the manufacturer, who maintains ownership of his valuable materials. It costs some at first, not using the cheapest you can get, but has shown to pay back. Amongst the cheaper alternatives we find **'unmarketables'** like toy's plastics off-gassing chorine, that need to be abandoned.

Cradle to cradle is bio-inspired. Natural systems in their **ecological intelligence,** demonstrate cycling of nutrients, interdependence, abundance, diversity and power of regeneration. Like nature we should become **eco-effective,** meet our own goals while others prosper, rather than **eco-efficient,** merely minimising our impact and taking the shortest route to our ends. In stead of being **less bad**, we can be good, when we make **our waste our food**.

Alongside **lifecycle assessment** and **design chemistry** (designing materials for their use and life after use), there is the **Cradle to Cradle design protocol**:

Five stages of redesign describe different levels of intervening, chronologically applicable to products around us.

1. Produce without harmful contaminants.
X-list materials (like PVC, cadmium, lead an chlorine) are taken out of the product and alternative materials are found that do not require a change of production process.

2. Follow informed personal preference.
Chemical contents and social conditions in bought in materials are not always traceable within an economic timescale. Choose on available information and common sense, and ask suppliers to validate themselves.

3. Create a passive positive list.
Research the entire pallet of materials and chart all ingredients, waste in production, social circumstances, lifecycle analysis. Create a positive list of beneficial materials that could phase out the harms and pick the easy improvements.

4. Activate the positive list.
Here we stop making the product less bad, and start making it good. The product is fundamentally redesigned from p-list materials only. Materials are no longer viewed as eternally part of the product, but in a cycle of their own, brought together for a temporary function.

5. Rediscover.
Review the design assignment beyond the biological and technical cycles. Think of auxiliary benefits that a product could bring, like cleaning air or attracting solid pollutants. Think of products of service and try to dematerialise.

1.3 **Different C2C certificates;** respect learning

To express the degree of ‘C2C-ness’, you can get your product **C2C Certified** at the **basic**, **silver**, **gold** or **platinum** level. Sustainable design methods recognise that given a state of the art, a product may not be completely sustainable in its smallest parts because feasible alternatives do not yet exist. Rather than justifying some unsustainabilities, they are defined and have to be dealt with later. Annual recertification demands progress on these fronts. This results in four levels of certification, summarized below:

Source: Outline of C2C certification v 2.1 [MBDC, 2008]

CRADLE TO CRADLE CERTIFICATION^{CM} CRITERIA

	Basic	Silver	Gold	Platinum
1.0 Materials				
All material ingredients identified (down to the 100 ppm level)	●	●	●	●
Defined as biological or technical nutrient	●	●	●	●
All materials assessed based on their intended use and impact on Human/Environmental Health according to the following criteria: ***Human Health:*** Carcinogenicity Endocrine Disruption Mutagenicity Reproductive Toxicity Teratogenicity Acute Toxicity Chronic Toxicity Irritation Sensitization ***Environmental Health:*** Fish Toxicity Algae Toxicity Daphnia Toxicity Persistence/Biodegradation Bioaccumulation Ozone Depletion/Climatic Relevance ***Material Class Criteria:*** Content of Organohalogens Content of Heavy Metals	●	●	●	●
Strategy developed to optimize all remaining problematic ingredients/materials	●	●		
Product formulation optimized (i.e., all problematic inputs replaced/phased out)			●	●
No wood sourced from endangered forests			●	●
Meets Cradle to Cradle emission standards			●	●
All wood is FSC certified				●
Contains at least 25% GREEN assessed components				●
2.0 Material Reutilization/Design for Environment				
Defined the appropriate cycle (i.e., Technical or Biological) for the product and developing a plan for product recovery and reutilization	●	●	●	●
Well defined plan (including scope and budget) for developing the logistics and recovery systems for this class of product			●	●
Recovering, remanufacturing or recycling the product into new product of equal or higher value				●
Product has been designed/manufactured for the technical or biological cycle and has a nutrient (re)utilization score >= 50		●	●	●
Product has been designed/manufactured for the technical or biological cycle and has a nutrient (re)utilization score >= 65			●	●
Product has been designed/manufactured for the technical or biological cycle and has a nutrient (re)utilization score >= 80				●
3.0 Energy				
Characterized energy use and source(s) for product manufacture/assembly	●	●	●	●
Developed strategy for using current solar income for product manufacture/assembly		●	●	●
Using 50% current solar income for product final manufacture/assembly			●	●
Using 50% current solar income for entire product				●
4.0 Water				
Created or adopted water stewardship principles/guidelines		●	●	●
Characterized water flows associated with product manufacture			●	●
Implemented water conservation measures				●
Implemented innovative measures to improve quality of water discharges				●
5.0 Social Responsibility				
Publicly available corporate ethics and fair labor statement(s), adopted across entire company		●	●	●
Identified third party assessment system and begun to collect data for that system			●	●
Acceptable third party social responsibility assessment, accreditation, or certification				●

2 **The C2C toolbox;** standing on the shoulders of giants

The principles mentioned in section 2.2 are: The two cycles, Design for disassembly, Products of service, eco-effectiveness, lifecycle assessment, design chemistry and the five stages of redesign. Not mentioned but also featuring in the book is the triple-E pyramid. These tools will be elaborated below. But first: an explanation of the origin of these elaborations.

2.1 **Criticism;** C2C is void

Cradle to Cradle receives criticism on mainly two points: 1) The book does not offer well-defined strategies that are usable in a design process and 2) C2C uses a lot of strategies that are mainstream in sustainable design. The conclusions that are drawn are respectively 1) It is not useful to work with and will remain a utopian concept and 2) It is nothing new so one is better off using the known principles in their known context. From earlier studies (internship at Innovaders, 2007, Building C2C, 2008) I have learned that the points of criticism are valid, however I draw different conclusions.

The tools of C2C are under construction. They require interpretation, variation and experimentation to evolve into transferable methods. Designers using the C2C paradigm are required to think and invent, this is hardly a loss.

Most of the comprehensive tools do already exist, although these are not properly referenced in the book. Instead of arguing that these tools may or may not be a C2C concept, I would propose to see if they give better results within the C2C framework; the whole will be more than the sum of parts.

These are the reasons that the elaboration of C2C tools below are informed not just by the book, but by other sustainable methods and personal preference as well.

2.2.1 The two cycle wall

After disassembly, the product will have to be consumed entirely by two cycles. The biological cycle reuses the materials by biodegradation; this pile will be separated in as few as possible processes of natural metabolism. In the technical cycle the materials will be reused in as few as possible reforming or reuse processes. Materials that can not be taken apart effectively will have to be chosen to have the same reuse process.

Conception

In our studio we will have two sheets alongside; one for each cycle. For every part or sub-assembly that we know will be in the product, a post-it will be placed on either sheet, choosing the suitable cycle. If it is a sub-assembly, the monomaterial parts are posted around it and parts that are incompatible with the chosen cycle are marked with a red sticker. If parts or sub-assemblies are connected in the product we will connect them with a pinned rope on the sheets, mentioning the fixture. This stage is aided by research into the composition of parts and sub-assemblies.

Optimisation

The parts with red stickers will be dealt with in one of three ways. First we have to see if the part can be made from another material that is compatible for reuse. If not, we have to make the part so that is can be disassembled, moving the post-it to the other sheet (cycle) and naming the fixture with the rope. If this part can not be designed ether cycle or for disassembly it will have to be replaced with alternative technology, starting again with the conception phase. The connections (indicated with the ropes) across the sheets have to be optimised for easy disassembly. This stage requires research on alternative materials with suitable specifications.

Definition

When the stages above are complete, all the parts that comprise the product are on the sheets. They are monomaterial, grouped in sub-assemblies, designated to either cycle and tied when they are connected. With this information we will make a design for disassembly tree. Starting with the product at the top, it is split in first order separation. This separation requires blunt human labour and basic tools like screwdrivers or standard automated processes such as shredding and magnetic separation. Parts that have to be disassembled further are split in a second order separation requiring skilful labour, custom tools or custom automated processes. At the bottom, all the separated materials are designated a specific possible reuse. These could be: algae food, compost fermentation, refit into new products, melting or incineration. This stage necessitates knowledge of reuse processes and may require prototypes to evaluate disassembly steps.

2.2.2 Design for disassembly (DFD)

The design for assembly (DFA) method is comprehensively described in the “Techniek 2 dictaat” [IDE342; Ruwe, Veefkind, Koudijzer, 1996] of the IDE bachelor. A product is defined in this method by successive manipulations of parts, calculating and optimising the time it takes for the product to be put together. Because the manipulations are largely the same for assembly and disassembly, this method seems suitable for DFD. Where we have to divert, we will note this in an evaluation of the DFD tool.

2.2.3 Products of service brainstorm

At the beginning of the design process we have to ask whether the product, or parts of it, can be replaced by services. First we have to establish the needs of the target group that are now fulfilled with unsustainable products, and the cultural boundaries that limit the range of alternatives. This will be done by means of cultural probing.

The needs will be separated into HCY’s; How Can You’s (HKJ’s in Dutch). For some interesting HCY’s we will try and conceive services. The services might replace (parts of) the product or add to its value. In later design stages we will detail the product alongside the services.

2.2.4 Eco-effectiveness brainstorm

In stead of minimizing the impact of our product, we should ask if it can contribute to biological or technological processes, whilst doing what it does. The options should not be additional, like a camera with a CO_2 filter, but integral, like a copier making O_3 (Ozone), meaning that the beneficial function is related to the intended function.

One option is ‘waste = food’; a T-shirt becomes a fertiliser and a frame becomes a blank. Another option is ‘upcycling’; PET is purified trough melting, a car is upgraded with a new engine. More options may emerge.

Start by listing the primary and secondary functions of the product and likewise for the main parts of sub-assemblies. For each function, ask who can benefit from it and how. Choose interesting options to elaborate in the next design phase. This brainstorm is preferably a multidisciplinary one as biologists, chemists, materials engineers, physicists and marketers know better what is beneficial for them or the processes they know than designers do.

2.2.5 Life Cycle Assessment (LCA)

For this tool I refer to the European Platform on LCA by the EU Joint Research Centre, Institute for Environment and Sustainability (EPLCA project by JRC-IES [lca.jrc.ec.europa.eu/EPLCA]) and milieugerichte productontwikkeling [Remmerswaal, 2002]. Operations include describing materials and processes for the cradle to grave life of the product and all its materials, assessment trough software like Ecoscan and Idemat, finding alternatives and evaluating them. LCA is a required tool for C2C certification. In the design process (not in a redesign process) a quick assessment of an alternative existing product would be performed in the analysis phase, a thorough LCA is done on the final product in detail design.

2.2.6 Design chemistry (DC)

Design chemistry is an essential part of C2C design; the consultancy that invented C2C is MBDC: McDonough & Braungart Design Chemistry. Braungart is also executive director of EPEA, a company that makes materials. DC means conceiving materials for their intended production method, use and reuse, rather than picking existing materials. This is out of the league of product design engineers and requires chemists, process engineers and material engineers. Our role as designers is to list the demands of a material in terms of mechanical properties, production processes and environmental constraints, and translate them into design assignments for external parties.

An insightful and comprehensive method related to DC is Industrial Ecology. Materials are not regarded merely in their use in the product, but as part of the larger process of material production, forming, combination, separation, reuse and reforming. Further elaboration of DC into a design tool requires knowledge of industrial ecology.

2.2.7 The five stages of redesign

As described in section 2.2 the five stages named in the book are: 1) produce without harmful contaminants, 2) follow informed personal preference, 3) create a passive positive list, 4) activate the positive list and 5) rediscover. For our use, the stages have to be formulated as stages of design (in stead of redesign), being analysis, synthesis and detail design in short. In that instance, the x-list with substances that may not be used is of little value in first two phases as materials are defined only in the detail design phase. In the synthesis, materials can be proposed. Here the positive list or p-list, with beneficial alternative materials can be of value. Rediscovery should happen at the beginning of the synthesis phase, before concepts are formed. Formulated in terms of the design phases, the 'five' stages of redesign are therefore:

Analysis

Analyse the needs with target group research tools. Analyse suitable available technology in terms of specifications, processes, materials and labour conditions. Mark problematic materials in comparable products using a MET (materials, energy, toxicity) matrix. Browse material databases for inspiration.

Synthesis

Brainstorm on products of service using the needs listed in analysis (reinventing). Choose amongst available technology by successive distinction on specifications (calculating mechanical demands), materials (using the two cycle tool), processes (by use of LCA) and labour conditions (by informed preference). Elaborate the material choice using a p-list for the MET matrix problems.

Detail design

Create the disassembly tree (from the two cycle tool), activating the p-list. Create strategies for any remaining x-list materials. Optimise production for energy and toxicity. Design the collection and reuse system.

2.2.7 Triple-E pyramid

The three E's are Equality, Ecology and Equity. You are not mistaking if it reminds you of People, Planet, Profit; the triple-P bottom line. It is a brainstorm tool. Draw a triangle and call each corner one of the E's. Describe what the product does for each of them, for example: This product will give personal freedom trough mobility, We can make money by selling it for more than the costs. In production, it purifies water. Think of many benefits for each corner.

Next, divide the triangle in successively smaller triangles, creating middle points. In the equity corner towards equality, ask questions like 'do employees receive fair wages?'. Equity towards ecology: 'How can we make the sustainable strategy a competative advantage?'. In between equiality and ecology one could ask 'do employees have a healthy work environment?'.

This brainstorm should reveal many ways in which the product can be good beyond the perception of the producer and consumer.