Design in Harmony with Natural Cycles

The Cradle to Cradle Framework

Full Circle – An organization pursuing sustainability as a growth opportunity engenders a focus on enhancing benefits (not only reducing costs) through its decision-making and actions – taking an approach of maximization rather than minimization. The organization can understand the perspective of "people, planet and profits" as expansionist and enabling leadership through the achievement of advanced success metrics. For example, the concept of good design of products and services should move beyond typical measures of quality – cost, performance and aesthetics – to include and apply new objectives, such as ecological intelligence and social responsibility. Change towards sustainability requires a company to reorient its goals, employ innovation and creativity, prevent problems and waste from being created in the first place, utilize more comprehensive metrics, and engage all stakeholders in both the vision and implementation of a positive future.

The Cradle to Cradle framework moves beyond the traditional goal of reducing the negative impacts of commerce ("eco-efficiency") to a new paradigm of increasing its positive impacts ("eco-effectiveness"). At its core, Cradle to Cradle design perceives the safe and productive processes of nature's "biological metabolism" as a model for developing a "technical metabolism" flow of industrial materials. Product components can be designed for continuous recovery and reutilization as biological and technical nutrients within these metabolisms. The Cradle to Cradle framework also addresses energy, water and social responsibility through the following tenets:

- Waste equals food. Design products and materials with life cycles that are safe for human health and the environment and that can be reused perpetually through biological and technical metabolisms. Create and participate in systems to collect and recover the value of these materials following their use.
- Use current solar income. Maximize the use of renewable energy.
- Celebrate diversity. Manage water use to maximize quality, promote healthy ecosystems and respect local impacts. Guide operations and stakeholder relationships using social responsibility.

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Pursuing Cradle to Cradle strategies for a product, process or entire company can spur creativity and grow new business opportunities. Expanding the definition of quality by designing eco-effective products can provide competitive advantage, differentiate a brand, attract and retain customers, and reduce long-term risks.

Starting At The Bottom

In action, the Cradle to Cradle framework can be applied to assessing the human and environmental health characteristics of materials throughout their life cycles, product recyclability/biodegradability, effectiveness of product recovery and recycling, renewable energy use, water stewardship, and social responsibility, as well as optimizing any current weaknesses.

The primary application of Cradle to Cradle by McDonough Braungart Design Chemistry (MBDC) to date, has been under the principle of "Waste equals food," or restated, "Safe materials cycling in closed loops." In order to understand whether materials can be safely cycled as "biological nutrients" and "technical nutrients," they should be evaluated for their human and environmental health characteristics, from production through use and post-use disposition, and recyclability/compostability:

First, each material must be broken down into its individual ingredient chemicals (e.g., a printing ink can contain a pigment, defoamer, surfactant, resin/polymer, wax, solubilizer, antioxidant and other additives). Simply knowing the type of material usually is insufficient for a full evaluation of material health. For example, knowing something is "high-density polyethylene" or a "printing ink with non-chlorinated pigments" does not identify the various additives that may be combined with the base material and typically are the most critical in determining the human and environmental health attributes of the finished material.

Collaboration with and education of the supply chain is critical to this inventory effort, in order to fill in the proprietary gaps not covered by Material Safety Data Sheets (MSDS). The ingredient data collection effort quickly can mushroom into numerous vendors and months of calendar time.

Second, each ingredient must be evaluated for its known or suspected human and environmental health hazards throughout its life cycle, by analyzing peer-reviewed research studies of the pure chemical's attributes measured using the criteria and cutoff values below.

Third, the chemical "profile" as a pure chemical then is placed into the context of the chemical's use within a material application. This in-situation (or *in-situ*) assessment may alleviate some of the ecotoxicity concerns associated only with the pure chemical.

Finally, the *in-situ* chemical assessments are combined together to develop an assessment of human and environmental health characteristics for a complete material and/or finished product, across their entire life cycles. In addition, the material's recyclability/compostability is evaluated, based on its own physical properties, irrespective of the relative availability of infrastructure for closing the loop or the Federal Trade Commission definition of recyclable.

- **Table 1: Human Health Criteria** These criteria are subdivided into priority criteria (most important from a toxicological and public perception perspective) and additional criteria. Substances that do not pass the priority criteria are automatically considered problematic and recommended for phase-out/replacement.
- **Table 2: Environmental Health Criteria** These criteria have immediate or long-term effects on environmental quality, including plant or animal life.

Material Class Criteria

Table 3: The following material classes are considered problematic because, at some point in their life cycle, they may have negative impacts on human and environmental health. For example, organohalogens tend to be persistent, bioaccumulative and toxic, or can form toxic by-products if incinerated.

Table 4: Using available research data, each chemical, material or product is ranked using the following rating colors:

Ingredient Optimization And Beyond

Using completed material assessments, product developers can select ingredients that are safe for human and environmental health and fully recyclable/biodegradable. In cases where materials fall short, alternative formulations should be researched collaboratively with vendors. A manufacturer also should explore various strategies for fully recycling or biodegrading its product, which often requires connections with external partners, such as customers, retailers, recyclers, public agencies, and nonprofit organizations. Fully closing the loop on materials requires their safe recovery and reformulation into new products or biodegradation into the soil.

In order to "use current solar income," the final manufacturing process and vendors' manufacturing should be powered by 100% renewable energy (e.g., solar, wind, low-impact hydroelectric, biomass) produced onsite, purchased directly from a utility, or offset with Green-e certified Renewable Energy Certificates (REC).

In an effort to celebrate diversity, manufacturers and their vendors should ensure they are using as little water as possible and ideally keeping that water within closed loops. In addition, water released to the environment should be of at least the same quality as before it was removed from a water source, to promote ecosystem and watershed health. Social responsibility should guide relationships with workers, local residents, customers, vendors, the larger business community, the government and other stakeholders.

Cradle to Cradle optimization may not be achieved easily or quickly, and may require continuous improvement over time. For example, performance and cost considerations also may prevent preferred solutions from coming into use in the short term, but at least manufacturers are prepared with an eco-effective solution once other market conditions are met. The Cradle to Cradle goal may take a long time to completely realize for a particular product or industry, but designers, material fabricators and manufacturers should accept the challenge, establish a trajectory toward this ideal, and begin to implement strategies to help them achieve it. Leveraging this expanded notion of "good" design will help create materials and products that benefit the company, its stakeholders and the environment.

Table 1

Criterion	Description
Priority Criteria (rated problematic if known or suspected)	
Carcinogenicity	Potential to cause cancer
Endocrine Disruption	Potential to negatively effect hormone function and impact development
Mutagenicity	Potential to damage DNA
Teratogenicity	Potential to harm fetus
Reproductive Toxicity	Potential to negatively impact reproductive system
Additional Criteria	
Acute Toxicity	Potential to cause harm upon initial, short-term exposure
Chronic Toxicity	Potential to cause harm upon repeated, long-term exposures
Irritation of Skin and Mucous Membranes	Potential to irritate eyes, skin, and respiratory system
Sensitization	Potential to cause allergic reaction upon exposure to skin or airways
Other	Any additional characteristic (e.g., flammability, skin penetration potential) relevant to the overall evaluation but not included in the previous criteria

Table 2

Criterion	Description
Fish Toxicity	Measure of the acute toxicity to fish (both saltwater and freshwater)
Daphnia Toxicity	Measure of the acute toxicity to Daphnia (invertebrate aquatic organisms)
Algae Toxicity	Measure of the acute toxicity to aquatic plants
Persistence/Biodegradation	Rate of degradation for a substance in the environment (air, soil, or water)
Bioaccumulation	Potential for a substance to accumulate in fatty tissue and magnify up the food chain
Climatic Relevance	Measure of the impact a substance has on the climate (e.g., ozone depletion, global warming)
Other	Any additional characteristic (e.g., soil organism toxicity, WGK water classification) relevant to the overall evaluation but not included in the previous criteria

Table 3

Criterion	Description
Organohalogen Content	Presence of a carbon-halogen (i.e., chlorine, bromine, or fluorine) bond
Heavy Metal Content	Presence of a toxic heavy metal (e.g., antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, mercury, nickel)

Table 4

GREEN	Ingredient/material is preferred for use.
YELLOW	Ingredient/material is acceptable for use. Associated with slight to moderate human and/or environmental health hazards; suitable for continued use until a GREEN alternative is found.
RED	Ingredient/material is problematic. Associated with one or more serious human and/or environmental health hazards (e.g., polyvinyl chloride, toxic heavy metals, halogenated organic substances); should be phased out as quickly as possible or carefully maintained in closed-loop life cycles without any risk of leakages, if required for product performance and no viable alternatives currently are available.
GREY	Incomplete data. Complete ingredient data is not available or evaluation data is not available; data should be collected or ingredient should be phased out of use.

See also our in-depth interview with Michael Braungart on pages 1 and 7.

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BASF Chelating Agent Plant On Stream Ahead of Schedule After 18 months of construction, the new plant expansion for BASF's chelating agent Trilon M has now been brought on stream at the BASF site in Ludwigshafen, Germany, three months ahead of the scheduled date. Expansion of the Trilon M plant has created 18 new jobs in Ludwigshafen.

The plant now provides BASF with a global annual production capacity of 120,000 t for chelating agents, which the company says is its response to increasing global demand. The company said it expects double-digit percentage growth rates for environment-friendly chelating agents. Apart from Ludwigshafen, BASF also manufactures chelating agents in Lima, Ohio (U.S.) and Guaratinguetá, Brazil.