Sustainability Watch

Cradle-to-Cradle Design

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Slow But Steady Adoption of Cradle-to-Cradle Design Techniques Bodes Well for Both the Environment and Businesses

Things to Remember

- Though we live in an increasingly product-consumptive world, a thoughtful and environmentally sustainable approach to product design, production, and disposal can ensure consumption does not come at a cost to the environment. Cradle-to-cradle design is such an approach.
- Cradle-to-cradle design draws on risk management strategies, industrial ecology, life-cycle assessment, and other environmental design and production strategies that take a systems approach to product development.
- Cradle-to-cradle principles are based on designing and producing products so that there is no waste generated. Cradle-to-cradle design also envisions that the energy supporting the methodology is sustainably sourced as well, relying mostly on solar power.
- Central to cradle-to-cradle design is the idea that all materials are either biological or technical nutrients. Biological nutrients are those that can easily biodegrade and are not harmful to humans or the environment. Technical nutrients are artificial materials that can be recovered through close-loop recycling for many lifecycles without losing their value.
- Cradle-to-cradle design relies heavily on the term "eco-effectiveness." Eco-effectiveness is meant to mirror cycles that occur in the natural world. Products and processes designed using cradle-to-cradle principles should be those that sustain people and the natural world.

The Basics

We live in an increasingly consumption-driven world and the proliferation of new products to market is almost overwhelming. While acquiring the latest "new thing" might be fun—and even life enhancing—there can be a price to pay when it comes to the ongoing onslaught of more, more, and more. That price is paid by the environment, when harmful materials or processes are integrated into the manufacturing and distribution scheme and used products are haphazardly discarded and replaced by new ones. This discard is often into the landfill; however, a thoughtful and environmentally sustainable approach to product design, production, and disposal that takes into account not only a product's birth into the marketplace, but also its end-of-life, is a very good way to ensure consumption does not come at a cost to the environment.

Cradle-to-cradle design is exactly this kind of sustainability-based product development methodology. It was popularized by Michael Braungart, a German chemist, and William McDonough, an American architect and designer. Cradle-to-cradle design draws on risk management strategies, industrial ecology, life-cycle assessment, and

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other environmental design and production strategies that take a systems approach to product development.

Cradle-to-cradle principles are based on designing and producing products so that there is no waste generated. Cradle-to-cradle design also envisions that the energy supporting the methodology is sustainably sourced. To be considered truly cradle-to-cradle, products cannot contain or produce toxic materials. Additionally, after the product's materials are recycled, they are expected to be of an equal or higher quality than when originally used, and not downgraded or contaminated.

Central to cradle-to-cradle design is the idea that all materials are either biological or technical nutrients. Biological nutrients are those that can easily biodegrade and are not harmful to humans or the environment. Technical nutrients are artificial materials that can be recovered through close-loop recycling for many lifecycles without losing their value. Biodegradable fabric is an example of a biological nutrient, while steel is an example of a common technical nutrient.

Cradle-to-cradle design relies heavily on the term "eco-effectiveness," which replaces the concept of "eco-efficiency." Eco-efficiency focuses on doing more with less material or redesigning to use less energy. Cradle-to-cradle views these actions as not bad per se, but still part of a fundamentally flawed system. One of the primary differences between cradle-to-cradle design and other environmental sustainability strategies is that cradle-to-cradle design encourages economic growth, development, and the use of materials—albeit in a different way than is conventionally practiced. This is an essential concept for many businesses to understand.

Eco-effectiveness is meant to mirror cycles that occur in the natural world—such as the life of a tree. A tree is able to make its own food, sequester carbon dioxide, create oxygen, filter water, produce fruit, provide habitat, and decompose at the end of its life. Products and processes designed using cradle-to-cradle principles should be similarly sustaining to people and the natural world. Rohner Textil AG, for example, has developed a textile using cradle-to-cradle principles that is made of biodegradable, non-toxic fibers that are said to be so benign they could be eaten. Their intended use, however, is for the upholstery of the Airbus 380. Additionally, because manufacturing this product results in a much cleaner effluent compared to traditional textiles, it is estimated that Rohner has saved 20 percent in production costs.

A distinct vocabulary is associated with cradle-to-cradle design. Upcycling is a term used to describe materials that are disassembled, sorted, and returned to the manufacturing stream. As opposed to recycling (or downcycling), upcycling is meant to denote the materials have lost no value or quality as a result of their processing. While a recycled material might be of a lower grade, an upcycled material is capable of being reused continuously for its original purpose.

Downcycling might occur if a product contains a thermoplastic and thermoset bonded together, precluding either from being repurposed because thermosets cannot be depolymerized. However, a thermoplastic alone, such as nylon, could be upcycled because it could be depolymerized and repolymerized into a usable material. Furthermore, if the processing removes heavy metals or other contaminants from the plastic, the outgoing material could be of a higher quality then the incoming nylon.

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This type of recycling process is called "closed-loop" because there is no loss of material as a result of reprocessing. Importantly, no waste is generated in a closed-loop system because every material is used as an input for new production. Ideally, the only other inputs would be energy from the sun. In stark contrast, in the current open-loop or linear manufacturing process, 90 percent of the material extracted for durable goods becomes waste.

As part of implementing cradle-to-cradle principles, several companies are shifting from selling products to leasing services (the Product Service Systems model). For example, a resin developed by 3form and Bayer Medical Science can be "rented" for a set period of time and then reclaimed for recycling into a new product. In such a business model, a manufacturer retains ownership of its material throughout its entire lifecycle. Customers will pay for the use of the material or product before returning it to the supplier, who reprocesses it for continued use.

Challenges

Implementing cradle-to-cradle design principles is often a difficult task for businesses, as it requires specialized design support tools and decision-making strategies. In addition, implementing cradle-to-cradle principles can represent a sea change in thinking for many businesses. Some have noted that the tools do not consider the organizational context in which they are being used.

Acceptable material sourcing is often the largest barrier to effectively designing and producing a cradle-to-cradle product. There are relatively few widely available materials that are completely safe to humans and the environment and are easily recycled.

Even with design strategies in place, for cradle-to-cradle design to reach its full potential a global supply chain of preferred materials must exist. Lack of market communication is a barrier to creating this reality. Also, while there is ongoing research by the scientific and business communities, much of the resulting information is kept private. Cradle-to-cradle design requires coordination among the entire supply and distribution chain.

Pressure to employ cradle-to-cradle design concepts and tools comes from many sources, including customers, international non-governmental organizations, and government agencies. In addition to environment, health, and safety considerations, design strategies must consider consumer preferences as well as the financial success of the firm.

Opportunities

Change management can be aided by decision-making tools, design support tools, and material flow tools. Decision-making tools help to define design strategy, guidelines, and applications. Design support tools are often in the form of computer models that aid in designing for disassembly, identifying areas for improvement with respect to environmental and health impacts, and optimizing time constraints with cradle-to-cradle principles. Material flow tools measure the relative environmental and economic impacts of material and energy use.

A potential solution for sourcing materials is a concept developed by Michael Braungart called Intelligent Materials Pooling (IMP). The underlying concept of IMP is to create a business-to-business pool of high-tech, high-quality materials that can be closed-loop recycled.

Upwards of 20 percent of chemicals used today are already closed-loop recycled. While developing cradle-to-cradle chemicals are costly, firms can recoup money in the long term. Dupont, for example, spends about $1 billion on R&D—the same amount it spends on regulatory compliance. By using cradle-to-cradle designs, it could be possible to eliminate regulatory costs in the design phase.

It is possible to imagine a future in which many products are sold as a service for a set period of time. Product Service Systems could be applied to anything from chemicals and carpets, to washing machines and televisions. Such a system could make a cradle-to-cradle industrial system much more practical.

Related Sustainability Watch Reports

- Life-cycle Assessment
- Industrial Ecology
- Extended Producer Responsibility
- Design for Environment
- Material Recycling
- Design for Disassembly

Further Reading

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