

Summary

Braungart and McDonough present with their book: "Cradle to Cradle remaking the way we make things" a framework for designing products and industrial systems in a sustainable way. Their framework is seen as an alternative for current sustainable designing. Furthermore, Braungart and McDonough state that they also deliver a design for industrial systems. This paper reviews their design from a systems perspective focused on technical recyclable systems. Critics argue the Cradle to Cradle design on several aspects. These aspects are reviewed and organized by using the Delft Systems Approach. Criticism is mainly focused on missing a clear design of Cradle to Cradle for the process and for the control of the process, excessive use of resources, legislation as input for control and solar energy as the main resource for energy. The main research question is: How is the Cradle to Cradle technical system designed?

Braungart and McDonough mention that only two kinds of products should exist; biological degradable products or technical recyclable products. These products therefore should only be produced in a biological degradable cycle or a technical recyclable cycle respectively. Braungart and McDonough state that a technical system should be a closed loop system. The Cradle to Cradle design is explained for a general industrial system; afterwards there will be zoomed in on the biological system and the technical system. Further research is done for the technical system focused on the Cradle to Cradle closed loop supply chain. The process itself is reviewed with a focus on the reverse logistics side (the recycle phase of used products) of closed loop supply chains and on the possibility to fully close a supply chain. The control of the process is also reviewed. How is the control function designed? Finally the applicability of the Cradle to Cradle standards as an input for the control function is reviewed. Braungart and McDonough state that legislation is unwanted for Cradle to Cradle systems. Research is done about the influence of legislation on closed loop supply chains. Also the criteria of the Cradle to Cradle certification are reviewed. According to Braungart and McDonough eco-effectiveness is the main criteria for Cradle to Cradle design. The term is reviewed and its interrelation with eco-efficiency is determined. According to the Delft systems approach the term eco-productivity is applicable.

According to the Cradle to Cradle framework an industrial system should be a cycle. The term Cradle to Cradle implicates that a product after use should return to its 'cradle' and be reused again.

Therefore a cycle is the ideal system for an industrial system. The supply chain needed for producing technical recyclable products in a technical system should be fully closed. Others argue the possibility of a fully closed supply chain, because in practice there are products that have degraded too much and cannot be reused again. Therefore incineration or landfill is unavoidable to certain extent.

For the control of the material flow of the closed loop supply chain Braungart and McDonough favor a leasing structure. Manufactures own the technical products and consumers can lease without liabilities. Critics argue that leasing as proposed by Braungart and McDonough should be further substantiated. Also a clear design for reverse logistics is missing. Literature shows that several organizational structures are possible for the reverse logistics chain. For instance legislation influences the choice for an organizational structure. To control the closed loop supply chain Braungart and McDonough favor a separate entity for maintaining privacy rights and material handling and present

Cradle to Cradle standards for the supply chain. These standards are mainly focused on the resource flow needed for production; energy, people, machines and water.

Braungart and McDonough argue that consumers should be able to consume as much as they want on the condition that the consumer products are either in the biological system or in the technical system. Critics show that a surplus of biological nutrients is ecological harmful and that depletion of resources should be prevented as much as possible. Also an increase in production and consumption causes an increase in energy usage. This energy should be delivered by solar energy in Cradle to Cradle terms. Though current solar technologies are not yet feasible to produce the capacity needed for a Cradle to Cradle technical system. The main Cradle to Cradle criterion is eco-effectiveness that focuses on delivering the right products. Where eco-efficiency focuses on producing more products with less resources. To meet the demand of sustainable energy for Cradle to Cradle products it is important to incorporate eco-efficiency as a criterion as well.

Concluding, Cradle to Cradle design presents an interesting framework for sustainable production but does not present a clear design of a Cradle to Cradle system. The design for an industrial system needs to be further substantiated. For the technical aspect system a closed loop supply chain is presented for producing and using technical recyclable products but with current knowledge it seems utopic to have a fully closed loop supply chain. Critics present several closed loop supply chains but all conclude that a fully closed system is not achievable. Braungart and McDonough do not present a design for the control function, except for the possibility of a separate entity as an organizational structure for control. Also standards are more focused on the resource flow rather than the material flow itself. In addition to the standards, legislation should not be disregarded as input for the control function in contrary to what Braungart and McDonough state.

Braungart and McDonough encourage the increase of consumption but a surplus in biological nutrients is still ecological harmful and current solar technologies do not have the capacity to supply sustainable energy for the production and usage of products. Therefore it is recommended to incorporate eco-efficiency as a criteria as well as eco-effectiveness.