# DESIGN STRATEGIES FOR CIRCULAR ECONOMY

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## Abstract

A Circular Economy (CE) values material, technical or biological, as nutrient. CE thinking seeks to accelerate the conversion of technical nutrient cycles along the lines of biological nutrient cycles by re-designing systems till the scale of the economy. Though the notion of products being technical nutrient exists, its situation as an outcome of design intent is not contextually made. One objective of this article is to situate design and nutrient cycles of the earth system as and within natural cycles. This situation emphasizes the mechanism by which design affects nutrient availability to vital earth systems and draws attention to the functions that nutrients afford and serve by default before being embodied in products by human intent. The first principle of CE seeks to eliminate waste and re-purpose nutrients with minimal energy. Towards this, the historic trend of perceiving waste is drawn and Gestalts identified to arrive at the concept of tenancy and inform design. Tenancy is defined as the duration for which the nutrient embodied serves some purpose. Identifying the 6R scenarios as nutrient re-purposing functions, corresponding design strategies are stated.

**Keywords**: Ecodesign, Sustainability, Inclusive design, Gestalts, Circular Economy

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# 1 INTRODUCTION

Circular Economy (CE) aims to accelerate the re-design of whole economies basing 'cradle to cradle' thinking as its engine(McDonough & Braungart, 2008)(Sawahata, 2014). The five founding principles of CE are: eliminate waste; diversity is strength; energy must come from renewable sources; prices must tell the truth; and thinking in terms of systems is key(Anon., n.d.). The first principle is described as follows, The biological and technical component parts (nutrients) of any product should be designed for disassembly and re-purposing. The biological parts are non-toxic and can be simply composted. The technical, polymers, alloys and other man-made materials are designed to be used again with minimal energy. CE thinking encourages a broad systems view of products, parts and materials as two types of nutrients: technical and biological. Identifying problems with linear thinking of the cradle to grave approaches, end-of-pipe treatments etc., CE's systems thinking equates waste to food and proposes to model technical nutrient cycles along biological nutrient cycles. This is construed to avoid the detrimental consequences as of outcomes of linear thinking even when systems so modeled are scaled up for the benefit of all humanity. The problems with soils going alkaline due to the overuse of fertilizer following the Green Revolution that identified, emphasized and linearly reinforced just one function of soil is an example in this regard(Pingali, 2012). Extensive use of pesticides without comprehending the systemic linkages to humans and birds through the food chain is another wide-spread example of the detrimental consequences of linear thinking. The principles of CE encourage cradle to cradle looping of biotic and technical (abiotic) nutrient, prescribing the involvement of both nutrients in as many loops/cascades of value as possible. As sustainability provides businesses with the broadest context in which to situate their value propositions, business needs to strategically involve CE principles in their vision, mission and objectives to be coherent and evaluate their sustainability performance eventually. As businesses, and economies in extension, need to embrace sustainability into their organizational thinking faster, it is opportune that lifecycle thinking deepens and supports sustainability coherently. This article attempts to include the concept of planetary boundaries and lifecycle thinking through the concept of tenancy to inform design strategies corresponding to the first principle of CE thinking.

# 2 DESIGNING-OUT WASTE

Column 1 of Table 1 lists the trend of 'waste' from something undesirable to something which is resource in itself. Column 2 lists the corresponding perception as a shifting trend between Gestalt foreground and background. Correspondingly, Column 3 lists thinking shifting from linear to circular.
Products are designed for meeting requirements during their use in the usage-phase of their life-cycle. This is the conventional and well-understood definition of functional performance. Given the concern for decreasing resource availability it is wise to design products for requirements arising from material extraction phase or end-of-life phase of the product where how less material could be extracted and how fast this material locked with the product can get back to the earth can be stated as functional requirements for the product (life-cycle) design. Designing to meeting either or both these requirements ensures that more material is available at any point of time for meeting requirements of the future. Resource depletion is only one consideration within the principles of circular economy and there can be many other functions which a product is also expected to deliver. In this sense, rather than a linear design of products the systemic design of product life-cycles assumes centre-stage with CE thinking. The definition of 'function' across the phases of product life-cycle according to CE thinking of material as nutrient needs to be emphasized. Re-purposing of CE seeks to find more functions to already embodied nutrient, in products or their parts. This makes dis-assembly and design for dis-assembly assume importance. And, along with this (design) strategies for possible problem scenarios that will be encountered need to be explicated. Column 3 of Table 2 lists design strategies along CE thinking for 6Rs of end-of-life (EoL), i.e. re-use, reduce, remanufacture, refurbish, repair and recycle.

*Table 1. Waste: Perceptual (Gestalts) and thinking (linear to circular) trends*

| **Idea** | **Gestalts**(Humphrey, 1924) | **Thinking** |
|---|---|---|
| **Waste** | Perceiving product as the foreground (positive) that is alone intended, useful and | Garbage disposal was the original issue as waste was from human settlements (Anon., |

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| | wanted. The rest is perceived as a useless and unintended residue that is an unavoidable consequence and hence as the unwanted. This makes it part of the (negative) background; Labeling unwanted as 'waste' is a consequence of its perceived uselessness | 1998). More recently the consideration of unintended outcome as waste is from a scientific outlook(Ostwalt, 1976) and the ensuing industrial activity(Wiener, 1989); Bountiful earth provides for all; resources are unlimited; Revolutionary and uncritical enthusiasm (technological adolescence) in mass-produce of the industry; cradle to grave |
| **Reduce waste** | Perception of positive and negative still the same but with the knowledge that the process of realizing foreground does not necessarily mean the generation of as/so much of 'waste'. Beginning of perceiving 'waste' as that being wasted i.e. the verb also | Incremental/continuous improvement: sending lesser material to grave; Realization of consequences of industrial revolution to resource availability(Anon., n.d.), local climate and in extension global climate(IPCC, n.d.) |
| **Zero waste**(Boulding, 1966)(Colon & Fawcett, 2006) | Utopian emphasis on 'waste' as that being 'wasted' with inklings of what could have been the foreground itself | Extreme position of incremental improvement; Radical innovation; Realization of local and global consequences of waste management; Utopian aims within the original sculpting paradigm. Why have waste at all but to fully utilize all resource? |
| **"There is nothing like 'waste'"** (Schick & Toth, 1993) **Waste is Food**(McDonough & Braungart, 2008) | Treating waste as resource itself i.e. as a positive foreground then and there or later, rather than being led by mere label or the phenomenon of labelling, 'waste'. Likening the importance of waste to 'food' thereby connoting the non-existence of anything that may be labelled 'waste' | Industrial ecology(Frosch & Gallopoulos, 1990); Systems Thinking; cradle to cradle; Material cycling thought along the lines of food and energy pyramids in ecology; Calling material as waste is a perspective; What it, *is*? Mere change of perspective does not change the nature of material itself at hand. To counter this negative label negatively, the phrase 'non-waste' is coined[Reference] for product |
| **'Wealth from waste'**(Khanna & Mohan, 1995) **or 'Waste to wealth'**(Pearce, 2011) | Ideological impact of the idea (phrase) derives from the 'shift' of perception facilitated by the juxtaposed Gestalts i.e. Not just the produce but even waste as a resource in itself can generate wealth | Constructing from 'waste' or extracting other embodied utilities from 'waste'[Cities as future mines(Jacobs, 1969)]; Resource as Re-source (Vezzoli & Manzini, 2008)(Manzini, 2009); Resource utility is seen cascading down to requirements of different scales being met justly/appropriately |

| | | |
|---|---|---|
| **Dematerialization**(Colombo, 1988)(Herman, et al., 1990) | Emphasis on resource extends backwards so as to see the products of the past and existing as those holding material (resource and nutrient) hostage(Jacobs, 1969); Product level barrier collapses: The absence of distinction between foreground and background is firmly realized; | Reflective thinking on decisions taken in the past; extending the reach of the sculpting paradigm; Epitome of material use-effectiveness realm: More from less; Re-thinking interventions of the past; Release more and more material from being a non-functional part of products |
| **Reducing Consumptive practices**(Brundtland, 1994)(Vlek, 1995) | Emphasis on resource extends further backwards so as to perceive users of the products as those who determine conditions to hold material (resource) hostage; tendency to perceive fellow-beings as resources as the barrier between products and individuals collapses(Heidegger, 1977) | Increasing affordance; Recourse to Conservatism: Reflective and critical thinking of past behaviour; Contented acceptance; the basis of anthropocentrism is questioned; Reducing the initiation of processes that stimulate the creation of products in an effort to reduce waste and other consequences (background) |
| **Reduce (consumptive) want/desires** | Further emphasis on resource extends further backwards and perceives users as fellow-beings including oneself as a possible user. Individual embodiment is also perceived as a resource. Starting to perceive the sameness out of which the background and foreground emanates. This is perceived at the interface between product and individual and interfaces in-between them | Dogmatic conservatism: What was, *is* the best and there is no reason to change that or invent things anew; Reflectance on self; thinking about thinking leading to self-actualization As personal barrier collapses, anthropocentrism collapses into humanism; Naturalism: Humans perceive themselves in their ecological role and not as agents claiming to be at the centre of change necessitating material consumption; "The earth has enough to meet every man's need but not greed(Gandhi, 2011)". Life-boat ethics(Hardin, 1968); Controlling reproduction(Hardin, 1968)(Ehrlich & Ehrlich, 2009); |
| **Being Unity** (Meadows, et al., 1972)(Meadows, 2009)(Mathews, 1999) (One with nature or our environment) | All pervasive sameness to start with. Foreground and background are just (temporal) notions spanning differentials that continuously dissipate losing distinction | Naturalism(Mathews, 1999); Affording affordance(Withagen, et al., n.d.): Person who feels the need, self-determines need and learns to design to satisfy it in his capacity; |

## 3 CONCEPT OF TENANCY AND METHOD

CE thinking seeks to systemically re-design products, organizations and the economy. At the product level, managing material lifecycle information (MLM), rather than that of product lifecycle (PLM) is increasingly considered better in: handling compliance issues at sourcing, avoiding costly re-work, resolving issues related to data inconsistencies and trust across various departments of the

organization. By definition, material in MLM covers compounds and elemental substances, which in CE parlance are referred as nutrients. The extension of lifecycle analogy to material entails the production and decomposition of material, akin to products. This breaks the fixation to product identity and suggests material to be perceived as being tenant of both naturally occurring objects (naturefacts) and man-made products (artefacts). In CE thinking, that which can be composted is termed biological nutrient and that which cannot is termed technical nutrient (collectively referred as 'entities' hereon). Parts that make products are categorized under these nutrient categories. Material is also a product, as a compound of elemental substances, and this allows the perception of substance as a tenant of material. Tenancy captures the concepts of continuum and dynamic due to which the identity of entities is rendered spatio-temporal and provided constitutionally. Metaphorically speaking, the identity of entities is a conduit within which flowing substance has some duration of residence or tenancy. Substance that flows through the property (geometric/spatial notion) of such conduits affords them with properties (chemical and physical) that hold for varying durations. The duration for which properties of entities hold determines the functional life of products. Depending on how 'function', is defined, life-term can be limited to just the usage phase of the product or all the phases of the whole product life-cycle encompassing utility, economic, social and environmental impacts. The idea to extract value and re-purpose of CE thinking seeks functions for the nutrient to serve in a systemic cascading manner before it is converted into the lowest form. This is different from the lifecycle idea of 'extending useful life', for two reasons: one, the identity of products is reduced to their constituent nutrient; and two, the identity of products holds only till the function defined in the use-phase is delivered. For these reasons the idea of CE thinking translates to extending the tenancy of the nutrient. Tenancy provides an encompassing spatio-temporal notion for nutrient in CE thinking from the standpoint of which perceptual trends of waste and 6R scenarios are listed to re-purpose functions and inform corresponding design strategies.

## 4 SITUATING DESIGN CYCLE IN NATURAL CYCLES

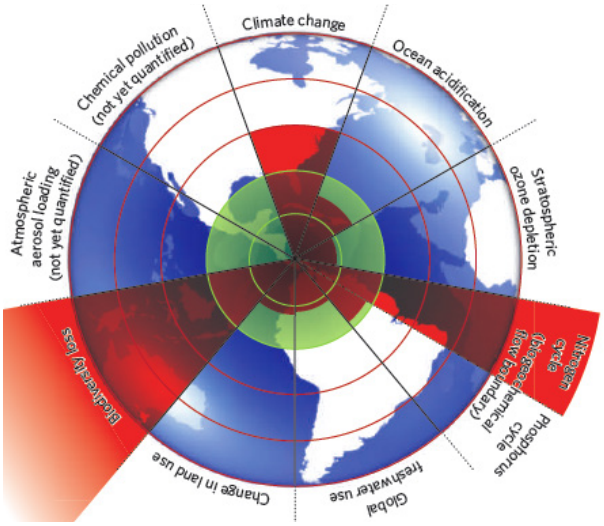


*Figure 1. Beyond the boundary. The inner green shading is a proposed representation of safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded (Rockström, et al., 2009).*

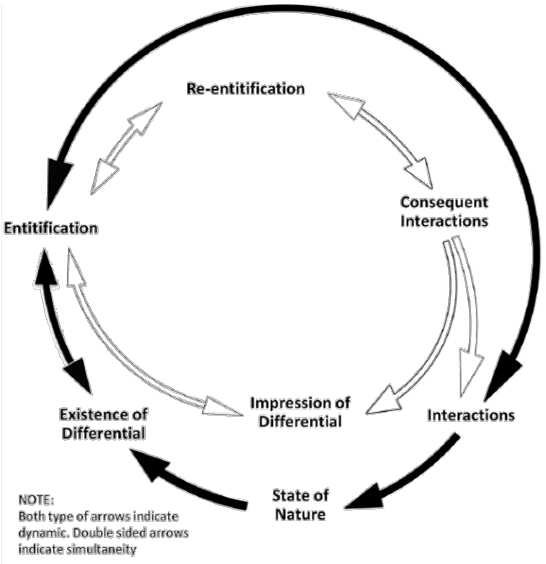


*Figure 2. Design in Natural Cycle. Outer Cycle in bold represents earth system cycles. Inner cycle represents design cycle of anthropogenic intervention (both are clockwise; two-sided arrows indicate simultaneity). Human action embodies nutrient (re-entitification) away from what would otherwise be available to life-supporting earth system cycles (Devadula & Chakrabarti, 2013), thereby affecting their intensity and the irreplaceable vital opportunities they provide.*

The identity shift from product to its constituent material and their life-cycles leads to an appreciation of material serving other functions than that could be humanely intended. The concept of planetary boundaries lists nutrient and material that are essential for life to sustain and to raise alarm wherever their prevailing loads/intensities cross boundaries demarcated safe. Resources afford opportunity and increasing resource scarcity decreases opportunity available to design products that satisfy human needs in the future. Hence it becomes necessary to also understand the shift of nutrient from natural cycles due to the globally distributed consumptive nature and scale of anthropogenic activity.
Human activity is known to affect earth systems at the planetary scale, the consequences of which prove detrimental to humans themselves. This indicates the closed loop nature of the systems we are part of emphasizing the necessity and importance of thinking systemically. A systemic notion of the earth comprises interactions between the atmosphere, bio-sphere, lithosphere and hydrosphere. Given the disruptive earth-scale impact of anthropogenic activity during what is coined, 'anthropocene', a fifth, anthroposphere or technosphere has been proposed (Steffen, et al., 2007)(Zalasiewicz, et al., 2010). All artefacts, technical or seemingly otherwise, are products of authorship and essentially involve the activity of design that comes with a representative specification of the artefact to be realized. The representation can be a tangible artefact in itself as in a drawing/blue-print or an intangible artefact (artefact of the mind), as in a mental image (specification) of what satisfies a requirement or a set of requirements of the client or customer.

*Table 2. Design Strategies for the first principle of CE*

| EoLScenario | CE Re-purposing description | Design Strategy for CE |
|---|---|---|
| Re-use | A. Components continue to serve their primary function as part of another product assembly<br>B. Components serve alternative functions other than their primarily intended function | A(a) No part should be the weakest link: Ensure that the use-phase life of all parts is maximized and equal to that of the product.<br>A(b) Use standard parts to the maximum: Parts should be able to serve more than one products' life-cycle. Can this be methodically afforded for all parts of products by design? |
| Re-manufacture | Re-install primary function with minimal technical nutrient and energy input | Wearing of parts in relative motion need be minimized by matching their hardness, lubricating interface,<br>Identify parts with less ratio of functional technical nutrient over total technical nutrient and design for their re-manufacturability; Re-manufacturable parts need to be accessed easily and quickly disassembled |
| Repair | Re-instate component interfaces essential for extending useful life i.e. serving primarily intended function. Consumable and replaceable components can be assembled anew to extend useful life. | Design for Disassemblability and Assemblability; Easy to learn from product manuals that need to be provided and inform re-pairing |
| Re-furbish | Replace/re-instate technical nutrient or whole components to re-issue warranty like on anew | Design for Disassemblability and Assemblability; Easy to learn |
| Re-cycle | Re-claim technical nutrient eg. stock from scrap metal | Design parts to be made of recyclable materials; Recyclable parts need to be accessed and easily disassembled in less time |
| Reduce | Aim for material use-effectiveness rather than efficiency alone. Achieve intended function using lesser material to retain material for serving earth functions or other humanely intended ones | Optimize product weight to achieve its intended functions. Reduce weight (mass) unless needed for inertia |

| | | |
|---|---|---|
| Re-design | Re-designing the whole economy based on circular principles mimicking biological systems | Consider all above stated strategies to extend life |

## 5 DISCUSSION

The amount of industrial raw materials needed for one unit of industrial production is now more than two-fifths of what it was in 1900, and this decline is accelerating. Thus, Japan, for example, in 1984 consumed only 60 percent of the raw materials required for the same volume of industrial output in 1973(Colombo, 1988). Each successive increment in per capita income is linked to an ever-smaller rise in quantities of raw materials and energy used(Herman, et al., 1990). If people, in their course of development aligned with that of their economy, see their needs to be relatively pre-potent and progressing similar to that proposed in theory of human motivation(Maslow, 1943), dematerialization at the individual level corresponds to a decreasing intensity of material required to satisfy hierarchical needs. From meeting physiological needs to self-actualization needs the material required individually goes decreasing culminating in the individual using his own embodiment for reflecting and contemplating on himself. Under such a condition it becomes possible of the individual to control consumption of material leading to controlling what he/she actually needs and desires. This is reflected by the trend in Column 1 of Table1. In this state, it may be said that the individuals use their embodiment as the artefact.

The impetus for sustainability or sustaining human development provides the broadest profile of requirements to be met by design. The concerns of unsustainability that are currently urgent arise from the consequences of technological use since the first industrial revolution. Primarily, these consequences are of the green house gases(GHG) released and the warming effect they have on the global climate affecting the planet's habitability for humans. The promise that the industrial revolution showed relegated the after effects of industrial mass production of goods into the background, and under the label, 'unintended consequences'. It has been argued (Wiener, 1989)(Pacey, 1999) that the nature of technology, and hence the nature of it's unintended consequences, developed based on science imbibes its positivist objectivity that contradicts anthropocentricity. The concerns of unsustainability are primarily about remedial and prevention of unintended consequences. Technology is the context of realizing (covering the case of finding value in natural objects i.e. naturefacts) or making artefacts. The mention of 'artefact' is often restricted to intentionally manufactured items in scientific parlance(Dunnell, 1971)(Ostwalt, 1976) while anthropological and archaeological parlance categorizes both intended and the unintended consequences of authorship as 'artefact'(Schick & Toth, 1993). Unintended consequences are otherwise referred in philosophy as 'residue' or 'debitage'. The remedial for addressing unsustainability requires accounting for the debitage in such a way that, whatever they have to be, in their life-cycle they do not affect the ability and capability of humans to develop. This is analogous to the interest with artefacts which within their life-cycle extend limited human abilities to unlimited capabilities positively. The metaphor in ascribing artefacts with life (*life-cycle*), is utility. And under the conceptual system of utility the artefact's primary function becomes its intended life failing to serve which it will be considered to enter post-use or end-of-life phase. However, utilitarianism can also exist for any secondary function that artefact's might serve as well as the unintended functions it can be put to use to, beyond their primary use-phase. Within all such utilitarian discourse of artefacts (products), the consequences of their making, irrespective of them being created simultaneously, seem to always be labelled as unintended and hence as something that can be considered as an afterthought. There is no reason why, other than pointing at our own affectation/obsession with artefacts, the idea of life-cycle for artefacts does not apply to their debitage. As the environment takes the exhaust of all such development changes to the nutrient (elemental) cycles(Rockström, et al., 2009) hold the key to accounting for the simultaneity of the life-cycles of artefacts and their debitage.

Human condition and the ontological simultaneity of the artefact and debitage afford the perception of just one as the foreground while the other automatically becomes the background. Once it becomes so, its recession phenomenologically reinforces the perception of the foreground so much so that one wouldn't come back to the point of considering ontological simultaneity before a long time has passed.

The perception of foreground and background is guided by Gestalt principles. Listing the changes in perceiving debitage, starting with how it was when humanity was affected with industrial produce, Column 2 of Table 1 shows how the evolution of idea of waste in Column 1 translate to a gradual shift of the Gestalts i.e. foreground with background into the post-industrial age. The thinning of the ozone layer because of long-lived aerosols and the subsequent exposure to ultraviolet irradiation, global-warming due to long-living industrial GHG emissions are some examples of urgent threats to our sustainability and have come to occupy our attention (have become a foreground) so much that the conventional ways of growth (now background, or the former uncritically accepted foreground) have now explicitly come under the scanner. These can hence be related to this phenomenon of shifting gestalts or the point of perceptual inflection.

The ontological simultaneity of the artefact and debitage is sequential phenomenologically as the ontological status of debitage is dependent upon that of the artefact as artefact is positively intended by the agent and not its debitage. Consequently, addressing the concerns of unsustainability, that necessitates the remedial of debitage of industry, requires it to be installed positively and acted upon as an act of authorship. For example, the undesirable 400ppm GHG concentration in the atmosphere needs to be brought below 250ppm by designing appropriate interventions, technological or otherwise. With the knowledge of debitage and the interest to progressively lessen it, it may be noted that such interventions should prevent their own debitage affecting humans over their life-cycle. If this is not so effected, humanity can get viciously caught in the cycle of remedial of remedies of remedies and so on rendering the concern of human sustainability, an ephemeral happenstance to be happy about temporarily. Entropy pessimism, to which many luminaries have prescribed(Wiener, 1989)(Russell, 1985)(Atkins, 1984)(Camus, 1955), also entails similar conclusions.

## 6 CONCLUSION

The idea of nutrient in CE thinking takes lifecycle thinking deeper and penetrates product identity to entity level identity that is of relevance to natural earth system cycles. This leads to better manage the consequences of making artefacts and hence the importance of design. Re-purposing with minimal energy according to the first principle of CE is captured within the concept of tenancy as increasing the tenancy of nutrient in service of a valuable function. Based on the prescription off the first principle of CE, eliminating and designing-out waste is studied in two ways: one, a historic perceptual trend of waste is drawn based on extensive review of literature; and, two, six scenarios of reduce, re-use, remanufacture, refurbish, repair and recycle are taken as re-purposed EoL functions to work out corresponding design strategies. The former study undertaken identified a shift of Gestalt foreground and background as a signature of the shift from linear thinking to systemic thinking while the latter study arrived at design strategies towards extracting more value out of technical nutrients or products. Implications of the shift of Gestalt have been discussed. Further, re-designing of business models developed under the linear thinking scheme of things to fit the goals of CE thinking needs to be undertaken.

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