Circular economy as an ecodesign framework: ECO III model

Economía circular como marco para el ecodiseño: el modelo ECO - 3

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Abstract

The current status of ecodesign and its relationship with circular economy are analyzed and an inter–relational philosophical model, ECO III, is proposed. This model takes on a new approach, proposing a response to current global environmental problems in view of the lack of resources and production models with increasing energy costs. The model also serves to introduce a new organizational and research culture as part of a system for industrial and technical-scientific innovation. The proposed model interconnects all system components and establishes connections and synergies between circular economy, ecodesign, sustainable development, and citizens' hopes, dreams, and practical needs.

Key words: ECO–III model, circular economy, ecodesign, sustainable design, EzioManzini, cradle to cradle, C2C, regenerative design, performance economy, industrial ecology, blue economy, biomimicry, permaculture, eco–innovation, eco–efficiency, eco–intelligence, triple–E system, sustainability, sustainable urbanization

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Introduction

The concept of sustainable development was defined at the 1992Earth Summit in Rio, being ratified by 180 countries and serving as milestone for economic and business sectors to begin to address environmental variables in their studies.

"Circulareconomy" has been referred to as "cradle-to-cradle economy", "C2C economy", and "closed-loop economy". It main proponents insist that it should not be consideredas an ecologicalmovement, but rather asadifferent way of thinking, a philosophy of design (Ellen Macarthur, 2013) (el original es del

año 2013, está correcto). One ofits main advocates, EzioManzini, presentssustainable designas a philosophicalapproach to a more social design, taking into considerationfactors suchas environment, culture, production processes, and materials (uses and aspects related to useful life).For Manzini, the role of a designernot only involves the creation of products, but also the building of everyday scenariosand newideasof social wellbeing (ManziniandBigues, 2000).

Ecodesign serves to manufacture products and servicesthat are efficient, sustainable,socially responsible,and competitivelydifferentiated. This study analyzes the inter-relationship between conceptsand tools, using circular economyas framework to developecodesignasa comprehensive circularmodelwherean array of philosophies converge—from the rudimentaryphilosophiesof the 70ssuch as "permaculture"to the more recentones such as "blue economy".

Inspiration: Schools of Thought behind Circular Economy

Permaculture

In the late70s, Australian ecologists Bill Mollison and David Holmgren defined the permaculture model as the consciousdesign andmaintainerof productiveagricultural ecosystems that havethe diversity, stability, and resilience of naturalecosystems,mimicking the patterns and relationshipsfoundin nature, which provide for their own needs, without exploiting or contaminating resourcesand are therefore sustainable in the longterm (Mollison and Holmgren, 1978).

Permaculture is a design discipline that applies and integrates ideas andconcepts ofmodern innovations(systems theory, biocybernetics, agroforestry systems, and so forth), conservation agriculture(lack and compaction of soils, permanentsoilcover),organic farming(nutrient recycling), andtraditional agriculture(rainwater infiltration) to improve soil performance andquality, reduce consumption of external elements,and protect biodiversity(Bell, 2005).

Industrial ecology (IE)

Given the non-sustainability of production processes, Robert Frosch and Nicholas Gallopoulos developed the Industrial Ecology (IE) model in 1989, which aims to help achieve sustainable development

The concept was used as the production modelof natural ecosystems, where industry is an interacting entity, establishing sustainable energy relationships, products and services,aswellas connections (similar to thefood network in ecology) among the different operatorsofthe industrial ecosystem used as basis to studymaterial and energy flow. This framework is also known as the "science ofsustainability" because of itsinterdisciplinary natureandbecause its principlescan also be appliedin the services sector. Industrial ecology grew rapidlyas a discipline and its positioning within the industrial andscientific sectors was strengthenedwith new developments, such as the launching of the *Journal of Industrial Ecology* in 1997; the creation of the International Society forIndustrialEcology—an interdisciplinary forumof natural andsocial scientists, engineers, policy makers, and practitioners—in 2001; and the launching of the journal*Progress inIndustrialEcology* in2004.

The natural step (TNS)

In view of the reality that humans are destabilizing their natural environment, in 1989 cancer scientist Karl-Henrik Robèrt proposed fundamental principles to reverse the situation and created the Natural Step (TNS), an organization with offices in 13 countries that gathers scientists, experts, and corporations dedicated to research, education, and advisory work in sustainable development. TNS provides integrated analysis tools, design criteria, and planning and management methods to build, step-by-step, a better future. The model proposes several socio-ecological principles for achieving sustainable development based on the laws of thermodynamics, the elimination of man's contribution to the systematic increase of concentrations of substances extracted from the lithosphere as well as that of substances produced by society, and the efficient use of resources to meet human needs.

Regenerative design

This philosophy was envisioned by Professor John T. Lyle of the Cal Poly Pomona University in California after conducting studies that postulated that all systems, beyond agriculture, can be arrangedin are generative way, emulating ecosystem functioning, where products are created and interact without producing waste (Lyle, 1994). Sustainable development aims for continued growth (without causing damage to the environment),where as regenerative design aims to create human systems that do not have to be discarded.

Cradle to Cradle (also called C2C)

In the nineties, an American architect, William McDonough, and a German chemist, Michael Braungart, proposed a design philosophy that considered all material involved in industrial and commercial processes to be nutrients, classifying them into technical and biological. This model focuses on designing for effectiveness in terms of products with positive impact, unlike traditional approaches that focus on reducing negative impacts. The underlying concept of this philosophy was inspired by biosphere transformation as model for transforming the flow of industrial processes in the techno sphere. For certain products, durability is not the optimal strategy because they end up in the garbage or they are difficult to recover by recycling. Therefore it is preferable to design consumer goods so that the purity of the material is maintained and their components are readily regenerated or returned to the earth (McDonough, 2007).

The C2C design model represents the application of circular economy to the world of industrial design and production, and proposes the bases of a new paradigm of intelligent design based on the closing of products' life cycles, as occurs in nature(McDonough and Braungart, 2005).

Commissioned by the city of Hannover, Germany, venue of the World's Fair EXPO2000, McDonough and Braun art prepared the "Hannover Principles Design for Sustainability" to ensure that the design and construction related to the fair would represent sustainable development for the city, region, and world. These principles are valid for any dimension of human creation. They advocate that industrial design, construction, and production can be maintained within nature's processes by using safe, more efficient materials and by producing goods without generating waste or toxic elements that degrade the environment (McDonough and Braungart, 2007).

Figure1 presents the Hannover Principles Design for Sustainability.

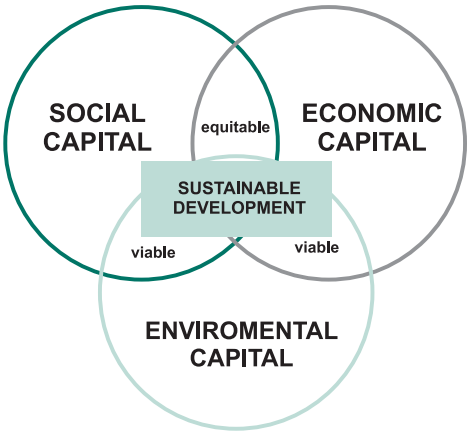

Figure 1. The Hannover Principles Design for Sustainability.

Natural capitalism

This model, proposed by environmentalist Paul Hawken, physicist Amory Lovins, and sociologist Hunter Lovins, is a critique of traditional industrial capitalism, which primarily recognizes the value of money andgoods as capital. Natural capitalism, on the other hand, extends recognition to natural capital and human capital. In other words, a shift is made from consumer economy to service economy and the profits obtained are reinvested to ensure natural resource conservation, constituting a guideline and action frameworks future endeavors can be environmentally and socially accountable. The transition towards natural capitalism involves four basic changes in business practices (Hawken*et al.*, 2000):

- Dramatically increase the productivity of natural resources by making changes in both production design and technology to better harness natural resources. These resource savings often yield higher profits, pay for themselves over time, and, in many cases, reduce initial capital investment.

- Shift to biologically inspired production models. Natural capitalism seeks not to merely reduce

waste, but to eliminate the very concept of waste. In closed-loop production systems each output is either returned to the ecosystem as nutrient or becomes an input for manufacturing another product.

• Move toward a solutions-based business model. The model of traditional manufacturing rests on the sale of goods. The new model is based, instead, on the flow of services, leading to a new perception of the value of goods as the continuous satisfaction of changing expectations for quality, utility, and performance.

• Reinvest in natural capital. Business must restore, sustain, and expand the planet's ecosystems so they can produce vital services and biological resources even more abundantly.

Performance economy

Walter Stahel, Swiss architect and industrial analyst, sketched the vision of an economy inloops andits impact on job creation, economic competitiveness, resource savings, and waste prevention (Stahel, 2010).

In 2013,Stahel founded the Product-Life Institute in Geneva, Switzerland, considered one of the main forums dedicated to sustainability worldwide.Its main objectives are to extend product life, remarket goods, conduct remanufacturing and technological upgrading activities, and prevent waste production. The Institute also impacts the service economy by highlighting the importance of selling services instead of goods.

Blue economy

In 2012, Belgian economist Gunter Paulila unched the Blue Economy model, whose paradigm was inspired by the natural world, holding similarities with the cradle-to-cradle and biomimicry models (Pauli, 2011). This model rejects the elitist attitude of green economy that offers environmental-friendly green products, but these are only accessible to an elite group with high purchasing power and have proven to be unsustainable. On the contrary, entrepreneurs and consumers have sustainable access to blue economy, being competitive, sustainable, and innovative. The approach emphasizes solutions determined by the local environment and physical-ecological characteristics. Blue economy defends not pursuing a sole benefit and seeks innovative ways of taking advantage of benefits arising from the production process and sources of income existing throughout the production process (no specialization or economies of scale) (Pauli, 2010). Risk is therefore diversified and the costs related to byproducts or waste disposal decrease, opening business opportunities for entrepreneurs.

Biomimicry

In 2012 Janine Benyus, president of the Biomimicry Institute defined the biomimicry model as the studyof nature's best ideas and subsequent emulation of these designs and processes to solve human problems, using artificial mechanisms to synthesize similar products. Biomimicry is innovation inspired by nature(animals and plants) in a biomimetic world. Fully biodegradable fibers, ceramics, plastics, and chemical products can be manufactured using solar energy and simple compounds.

The model is based on three key principles:

• Nature as model: study nature's models and emulate these forms, processes, systems, and strategies as examples of how to solve problems.

• Nature as measure: use an ecological standard to judge the sustainability of innovations.

• Nature as mentor: view and value nature based on what can be learned from it (Benyus, 2002).

Circular Economy

Circular economy is aphilosophyof systems organization inspired by living systems and seeks the change of linear economy (take, make, dispose)—increasingly difficult to implement because of resource depletion—towards a circular and regenerative model, asoccurs in nature, while also posing a huge opportunity for business innovation. Its practical applications in both economic systems and industrial processes have stead ilyincreased in recent years.Figure 2compares linear and circular economy.

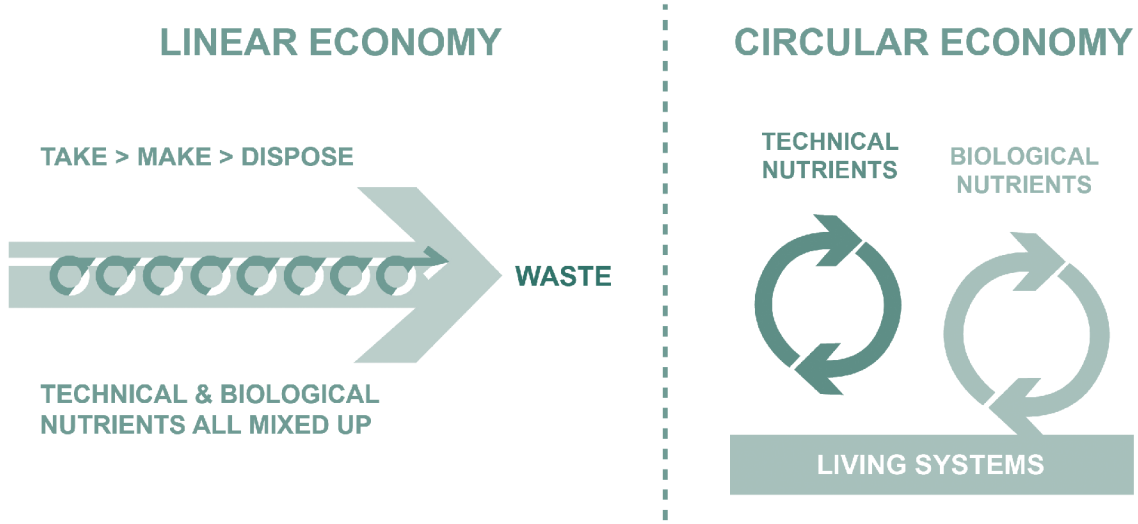

Figure 2. Comparison between lineal and circular economy
Source: Ellen MacArthur Foundation (2013)

Circular economy is applied not only to the designingof productsthat do not produce waste (ecodesign)and that are easily disassembled and refurbished, but also to the definition of socially intelligentbusiness modelsthat allow manufacturers toeconomicallycollectproducts for remanufacturing and redistribution (Goleman, 1999).

To achieve its goal, themodel divides material componentsinto two types:

• Biological nutrients, which are biodegradable and re-introduced into natureaftertheir use valueis no longerprofitable.

• Technical nutrients, which are designedtobe assembledand disassembledmanytimes andpromotethe reusing of materialsand energy saving(EllenMacArthurFoundation,2013b).

• The cradle-to-cradle design philosophy represents the implementation of circular economy to the world of ecodesign and industrial production. Figure 3 illustrates the circular economy model.

The concept of circular economy draws from several sources that refer to eco-intelligence, which is the ability to live causing as little damage as possible to nature, understanding the impact on the environment and everyday decision-making and, if possible, make decisions that benefit Earth's health the most (Ramírez and Galán, 2012).

Circular economy is based on the following

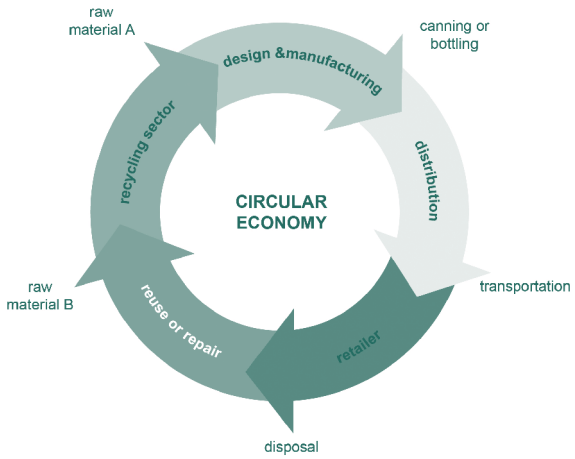

Figure 3. Circular economy model.
Source: Ellen MacArthur Foundation (2013)

principles:

• ***Waste versus food.*** The concept of debris or waste disappears. Products are removed from the market once they cease to be useful, and their biological components became part of natural or industrial (technical) cycles, with minimum energy consumption. Biological nutrients of fully biodegradable materials easily return to nature and form part of natural processes. Technical nutrients (mainly polymers or alloys) can be easily and inexpensively reused in energy terms.

• ***Natural systems more resistant and resilient due to enhanced diversity.*** These ecosystems are

characterized by having a greater diversity of organisms and increased interactions between them. A similar economic philosophy is applied to improve the response to economic and productive crises.

• ***System interrelationships.*** System elements are highly interrelated, showing nonlinear relationships. Both internal and external relationships of system elements are taken into account during the designing of the system.

• ***Reconceptualization of ownership model.*** Circular economy opts for a new model in which the production company leases the technology to the user. The manufacturer/producer upgrades the product from time to time, refurbishing/reusing obsolete equipment components.

• ***Renewable energy as energy source.*** Occurring in nature, this energy came from sources that are renewed over time. Circular economy opts for substituting fossil and nuclear fuels with renewable energy.

• ***Realistic prices.*** Prices reflect the actual cost of the product to promote a rational use.

There are three basic levels of action in circular economy:

• ***Level 1.*** The organization seeks greater efficiency through the 3Rs: **reduce** resource consumption and waste emissions, **reuse** resources, and **recycle** components.

• ***Level 2.*** Resources are reused and recycled within eco-industrial parks and interlinked industries so they fully circulate within the local production system.

• ***Level 3.*** Different local production and consumption systems are integrated, and resources circulate among industries and urban systems. This level requires the development of collection, storage, processing, and distributionsystems for each product at the local level.

The 3-level endeavor has an impact on resource recovery, "cleaner" production companies, and public facilities, increasing economic development through the investment in new businesses. Circular economy accordingly offers new business opportunities. On the regional level, an example of this could be integrated flow management between urban, suburban, and rural recovery systems such as biorefineries (using biomass discarded from rural and urban sources) that could convert these resources into bioenergy and biomaterials. The Eco-Industrial Park in Kalundborg, Denmark, is another good example (Ehrenfeld and Gertler, 1997).

Ecodesign

The evolution of the global market together with the increasingly challenging customer demand have created the need to implement policies and regulations toachieve the goal of sustainable development.

Ecodesign is a methodology to design industrial products that takes into account the environment during product development as an additional factor to those traditionally used for decision-making. When referring to ecodesign, Martin Charter, director of The Centre for Sustainable Design (CfSD), highlighted that international trends are demonstrating that concepts and tools such as environmental design, life cycle analysis, and extended producer responsibility are here to stay and are quickly becoming key tools for proactive organizations. Moreover, a growing body of evidence suggests that such approaches are exceptionally cutting edge, offering a range of benefits above and beyond just environmental benefits and simple compliance (Tukker*et al*., 2008).

Ecodesign not only opens commercial opportunities, but also helps address external threats. Production costs and product and resource consumption are reduced, product quality is optimized, product shelf life is lengthened, more sustainable and less energy - consuming resources are selected, cleaner technologies are sought and used, and waste/residue management costs are minimized, while complying with government regulations and satisfying consumer needs. Ecodesign can therefore help decrease the different environmental impacts of a given product or service throughout its lifecycle.

Life cycle analysis (LCA) models have been used for some time to study the flow of energy and materials of products or processes, leading to the preparation and proliferation of graphs and

pie charts needed to assess environmental impact within a given system. LCA effectively identifies opportunities for environmental improvement for the entire system(company, suppliers, distributors, users), and is a basic decision-making tool for Eco designing, selection of best available techniques, sustainable design, and so forth.

The life cycle of a product is understood as the series of stages of its useful life from generation through to end-of-life management or disposal. A product is not its end use, but rather a temporary state of matter and energy that provides a service.

There are two types of LCA, depending on the methodology used:

1. Qualitative LCA. Inexpensive, easy to apply, and does not require much understanding of ecodesign but providing ambiguous results. Provides an overview of the product's environmental impacts and indicates important environmental issues that should be addressed and pertinent actions taken. The MET (**M**aterials, **E**nergy, and **T**oxicity) matrix is a commonly used tool.

2. Quantitative LCA. Standardized by the International Organization for Standardization (ISO) (ISO 14040: 2006), this method is excellent to apply to products, processes, or activities, but expensive and complex. LCA addresses the environmental aspects and potential environmental impacts of the product throughout its life cycle and helps identify the most critical phases and main problems, which then serve as basis to identify solutions with the lowest environmental impact. Selected eco-indicators are used to obtain numerical results that can be easily interpreted to assess environmental requirements, as compared with complex analyses that require qualitative results.

Although ecodesign serves to innovate both systems and products, simpler solutions with short-term results are being proposed. Depending on what the enterprise wants to achieve, ecodesign can be implemented at four different levels, each with a different outcome.

- Level 1. Product enhancement: gradual and incremental enhancement.

- Level 2. Product redesign: new product based on an existing one.

- Level 3. New product in terms of concept and definition: radical product innovation.

- Level 4. Definition of a new system: radical system innovation.

Most enterprises have already given their environmental policies a global approach(based on circular economy), addressing the flow of energy and materials between the productive system and its environment and perceiving the environment variable as a strategic opportunity for competitive advantage (Ramirez, 2012).

The international standard ISO 14006,"Guidelinesfor incorporating ecodesign", was published in July 2011 and constitutes the first international standard for environmental management that integrates aspects related to the design, the evaluation of environmental impacts of designed products, and environmental impact management and treatment within an organization. It aims to assist organizations in their use of ecodesign as part of an environmental management system (EMS).

Ecodesign has been broadly accepted at the entrepreneurial level as a key tool to recycle materials, increase product durability, use recyclable materials, lower energy consumption, redesign/ refurbish products, decrease waste generated during the production process, increase the use of clean production technologies, decrease product weight and/or volume, promote the use of cleaner or reusable materials or containers, and decrease packaging. As a result, the eco-design approach to cleaner production has increasingly attracted more interest.

ECO-III Model: An inter-relational system

According to the report "Towards the Circular Economy" published by the Ellen MacArthur Foundation (2013?), several business and governments have actively explored opportunities to increase eco-efficiency as well as new forms of energy, paying less attention to the systematic design of reusable products—this clearly evidences the influence of

circular economy. The report also quantifies the economic benefits for businesses shifting towards circular models, and states that a subset of Europe´s manufacturing sector could save some 650,000 million Euros by 2025 if production systems are redesigned according the circular economy model.

A second report of the Ellen MacArthur Foundation, launched in Davos in early 2013, contained impacting figures: each citizen buys for consumption annually 800 kg of food and beverages, 120 kg of packaging, and 20 kg of new clothing and shoes, which, for the most part, are not returned from any further economic use. In the current "take-make-dispose" system, around 80% of these materials will end their useful life cycle as a pollutant. The report indicates that, even in the near term and without even taking excessively radical measures, using the circular economy system could increase the value recovered by 50% (Ellen MacArthur Foundation, 2013?).

• ***Shifting towards the circular process.*** Linear processes of the "take-make-dispose" type are characterized by the current production of goods, food, and energy, which has causednot only environmental problems such as climate change and pollution, but also social and economic problemssuch as resource scarcity. The essence of circular economy resides in designingproducts with no waste, thus facilitating disassembly and reuse, as well as defining business models that provide manufacturers with an economic incentive to collect, remanufacture, or redistribute products. Until now, the role of technology has focused on improving the efficiency of linear production processes, for example improving the internal combustion engine. The real goal is to shift from a linear economy to a circular economy, in which wastes are reintroduced into the production chain, largely limiting the need for resources and reducing environmental impact.

• ***Creating value.*** Potential strategies for creating value through effective environmental management should be studied. Cleaner production, ecodesign of products, and circular economy are processes that can enable organizations to meet their obligations regarding environmental management, while generating competitive advantages. Organizations must incorporate these aspects in strategic (long term) and operational (short term) decision-making processes. All cases show There is always opportunity to create value by preserving the costs of labor, energy, and materials used to manufacture finished goods. In mobile phones, for example, 50% of the input costs of materials could be saved by the effective use of remanufacturing. The implementation of circular economy mechanisms has important environmental impacts. For instance, the UK economy could save up to US$1.1 billion a year and reduce greenhouse gas emissions by up to 7.4 million tons just by keeping food waste out of landfills.

• ***The Three E´s.*** Based on the C2C model, the Three E´s refer to ecology, equity, and economy as the three pillars of sustainability and pose an alternative to the currently unsustainable model. Projects are designed taking into consideration their complete life cycle. The architecture of products and associated systems is integrated with the flows of materials, substances, and energy of both natural and technical ecosystems, achieving welfare economics that minimizes and solves environmental problems occurring since the beginning of the industrial revolution.

• ***Inter-relating processes.*** Ecodesign is understood as a methodology/tool to implement environmental improvements throughout the entire life cycle of the planned process, according to circular economy criteria, starting with the design, selection of materials, manufacturing, transportation, end use, and adoption of a strategic role. Ecodesign becomes the engine of innovation and a key step towards sustainability and responsible consumption. This tool, linked to the circular economy model and C2C principles, offers an alternative to the scheduled obsolescence that focuses on long-term sustainability strategies. A formula to efficiently use energy resources and materials, which are increasingly expensive and scarce, should be designed to achieve added value versus outsourced, low-cost production.

If a circular economy model is applied, the stages of a product's life cycle can be sustainable, for example by creating biodegradable or eco-friendly materials, using materials/byproducts of other industries, maximizing product reusability, designing removable or reusable components, minimizing waste at the end of the product's useful life, and using as much waste as possible as raw material for new processes.

The C2C design model represents the application

of circular economy to the world of industrial design and production, establishing the foundations of a new paradigm of intelligent design based on closing product life cycles, as occurs in nature.

Both practices are common in actions such as self-regulation. Visionary companies create their own systems for validating and measuring sustainable development goals, service economy (providing customers with a service and not necessarily a product), and dematerialization (the practice of replacing a product with a substitute that satisfies the same need).

Both disciplines (circular economy and C2C design model) coexist, are highly interrelated, and multidisciplinary in the implementation of sustainable production—the goal of any industry. Figure 4: Presents the ECO-III Model: the inter-relationships between circular economy, ecodesign, C2C, and the triple E's system.

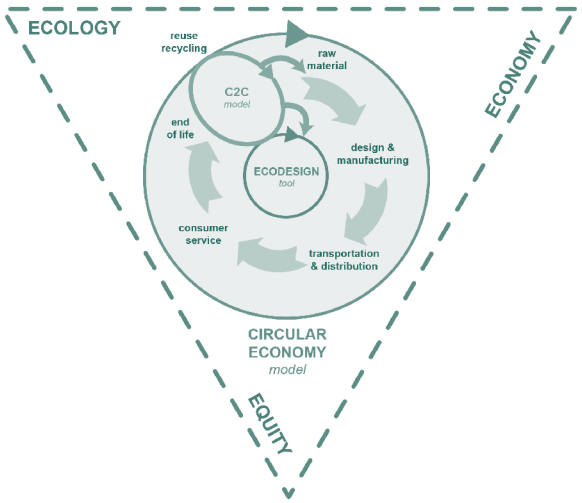

Figure 4. The ECO-III Model: Inter-relationships between circular economy, ecodesign, C2C, and the triple E´s system.

Conclusions

In a world of limited resources and gradually increasing energy costs, ECO-III is proposed as a new alternative production model. Considerable money and effort are invested in extracting materials from the soil (with limited resources) to manufacture products that are disposed of.

The model proposed was based on the analysis of different schools of thought, from the pioneers of the mid-70sto more recent philosophies such as circular economyandC2C—these two being the main references of the proposal.

Circular economy is the framework on which ecodesign is developed as an integral circular model. Ecodesign is used as the main tool to manufacture products and services that meet the criteria of efficiency, sustainability, social responsibility, and competitive differentiation.

TheECO-IIImodel proposes solutions to the growing need for resources while minimizing their environmental impact such as reintroducing wastes into the supply chain. It also assists organizations with environmental management, creating value and competitiveness that in turn yield both economic and energy benefits (savings).

This ECO-III model assumes a new organizational, operational, and research culture in a system of industrial and technical-scientific innovation, which is beginning to be referred to as R+D+i+E, E standing for Ethics: Accountability.

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