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Life Cycle of Products, Processes and Services

# CIRCULAR ECONOMY: A CRITICAL LITERATURE REVIEW OF CONCEPTS

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## Summary

The concept of a 'Circular Economy' has gained much traction in the global business community in the last 5 years. This holistic concept is supported by many stakeholders, but is mostly championed by the Ellen McArthur Foundation, who depicts it as a solution to sustainability and thriveability for both business and planet. The concept is usually presented as an alternative to the 'linear economy', which according to the Ellen MacArthur Foundation, is synonymous with a 'take-make-waste' approach to goods and services production. A Circular Economy is systemic by design, close-looped, restorative, waste-free, based on effectiveness and runs on renewable energy.

Circular Economy supporters portray it as an exciting and whole new way of transforming the economy into a regenerative economic system that will, as a baseline, exist within planetary limits. This attractive proposition is a social construct which grew out of the sediment layered by many different concepts that have been in existence for some time now. Thus, this critical literature review aims at presenting: 1) a general and conceptual portrait of Circular Economy as well as its underlying key concepts; 2) an explanation of Circular Economy's main tenets (from definition to implementation); and 3) a positioning and mapping of the various pre-defined concepts. Various analyses and key takeaways are provided all through the review.

**Circular Economy associated key concepts**

The list of defined concepts covers a large area of theoretical strands from which Circular Economy is derived. These ten concepts have all provided conceptual building blocks to understanding Circular Economy. They are presented in order of conceptual scale (from more to less encompassing):

- Sustainable Development
- Ecological Transition
- Green economy
- Functional Economy
- Life Cycle Thinking
- Cradle-to-cradle thinking
- Shared Value
- Industrial Ecology
- Extended Producer Responsibility
- Ecodesign

Sustainable Development is a polysemic and comprehensive concept that attempts to reconcile and fuse together three dimensions of development: economic, environmental and social. It ties in with Circular Economy through the economic and environmental dimensions, as well as through Corporate Social Responsibility, business' entryway into Sustainable Development. Ecological Transition is a polymorph concept, which encompasses theory, discourse and implementation and is mostly used by the French government to describe a multi-stakeholder process meant to direct society towards an economic development compatible with planetary limits. Green Economy is a concept that proposes economic solutions to mostly environmental issues through large, multi-partite policy proposals emanating from the United Nations and trickling through national governments and NGOs. The Functional Economy (also known as Performance Economy) is one of the main DNA strands (along with Cradle-to-cradle and Industrial Ecology) of Circular Economy. In order for business to decouple growth from resources consumption, new business models based on selling performance (or service) rather than goods, and on

retained ownership, must be adopted. This general idea can then spur innovation and create incentives to close production and consumption loops.

Life Cycle Thinking (LCT) is closely tied with Life Cycle Assessment (LCA) and Life Cycle Management (LCM). Its main goal is to reduce environmental impacts through an ISO landmarked, eco-efficiency based methodology which looks at each step of the product, process or service's life cycle, in order to design or redesign these with less embedded impacts. Cradle-to-Cradle Thinking is a concept that was developed and commercialized by Michael Braungart and William McDonough and is perhaps the main conceptual pillar of Circular Economy. Cradle-to-cradle champions eco-effectiveness (and dismisses eco-efficiency) through an approach based on cycling technical and biological nutrients in order to achieve healthy material metabolisms. Shared Value is a management approach that was developed by strategy authorities Michael Porter and Mark Kramer in order to reconcile capitalism with societal needs. The framework calls for business to create value by identifying and addressing social needs through new products and markets, redefined value chains and the creation of community development clusters.

Industrial Ecology, another major pillar of Circular Economy, is a research and application field that focuses on the creation and maintenance of a closed loop industrial ecosystem. Industrial Ecology aims at optimizing energy and materials, pollution and waste reduction through an economically viable transformation of industrial by-products or waste into inputs, with the ultimate goal of enabling industrial systems that mimic natural ecosystems. Extended Producer Responsibility (EPR) is a condition of the 'polluter pays' principle and aims at shifting a product's environmental responsibility over the full life cycle back towards the producer (and away from municipalities). Even though EPR has the potential to drive change over the full life cycle, it has mostly enabled postconsumer end-of-life management. Finally, the concept of Ecodesign is based on integrating environmental aspects into product development. Ecodesign can be used as a tool to implement LCA results or it can be a guideline, a checklist or an analytical tool that supports an eco-efficiency based product development process.

**Concepts timeline**

A timeline of the emergence and key moments concerning Circular economy and its associated concepts is provided. From this timeline, it is possible to note that the first conceptual seeds that lead to what is today encompassed by Circular Economy were planted at the end of the 19$^{th}$ century. In the twentieth century, the 1960s saw the emergence of concepts such as Spaceship Earth as well as the ancestor of LCA. The 1970s was a vivid decade for the commencement of concepts such as Cradle-to-cradle, Ecodesign, Industrial Ecology (through the first industrial symbiosis in Sweden) and major reports underlining the importance of adequate resources governance and closed loop economic systems. The 1980s were the set of the emergence of Sustainable Development and concepts such as the Performance Economy (better known today as Functional Economy) as well as the first articles on Industrial Ecology and the coining of the term 'Green Economy'.

From the 1990s and onwards, a plethora of concepts started to take foot in policy, management and scientific communities alike, starting with the term 'circular economy' itself in 1990 and the concept of Extended Producer Responsibility in 1992. Cradle-to-Cradle design starts to appear in the Hannover Principles in 1992, while the first book on Industrial Ecology is published and the United Nations Conference on Environment and Development (UNCED) establishes the concept of sustainable consumption. The 2000s was marked by the Johannesburg Plan of Implementation's (JPOI) report on Sustainable consumption and production (SCP), UNEP and SETAC's launch of the Life Cycle Initiative, the launch of the book *Cradle-to-cradle: Remaking the Way We Make Things*, the creation of the Marrakech process for SCP implementation and the founding of transition towns. In 2008, China became the first

country to adopt a Circular Economy law, while the United Nations Environment Programme (UNEP) was reviving the concept of Green Economy. 2010 marks the birth of the Ellen MacArthur Foundation, the main global champion of Circular Economy, followed in 2011 with the introduction of the Shared Value concept. In 2013 and 2014 respectively, France and Canada saw the birth of their own Circular Economy Institutes.

**Defining Circular Economy**

Following the concepts timeline, a portrait of what is (or should be) Circular Economy is tackled. First, a variety of definitions is presented and connected with the one holding the most pull, emanating from the Ellen MacArthur Foundation. This definition states that Circular Economy is restorative and eliminates waste by design through better materials, products and systems design, enabled by innovative business models. Circular Economy's principles are to embrace systems thinking, design out waste, embed diversity, use waste as food and run closed-loop systems on renewable energy. Figure 1 illustrates the Ellen MacArthur Foundation's vision for Circular Economy.

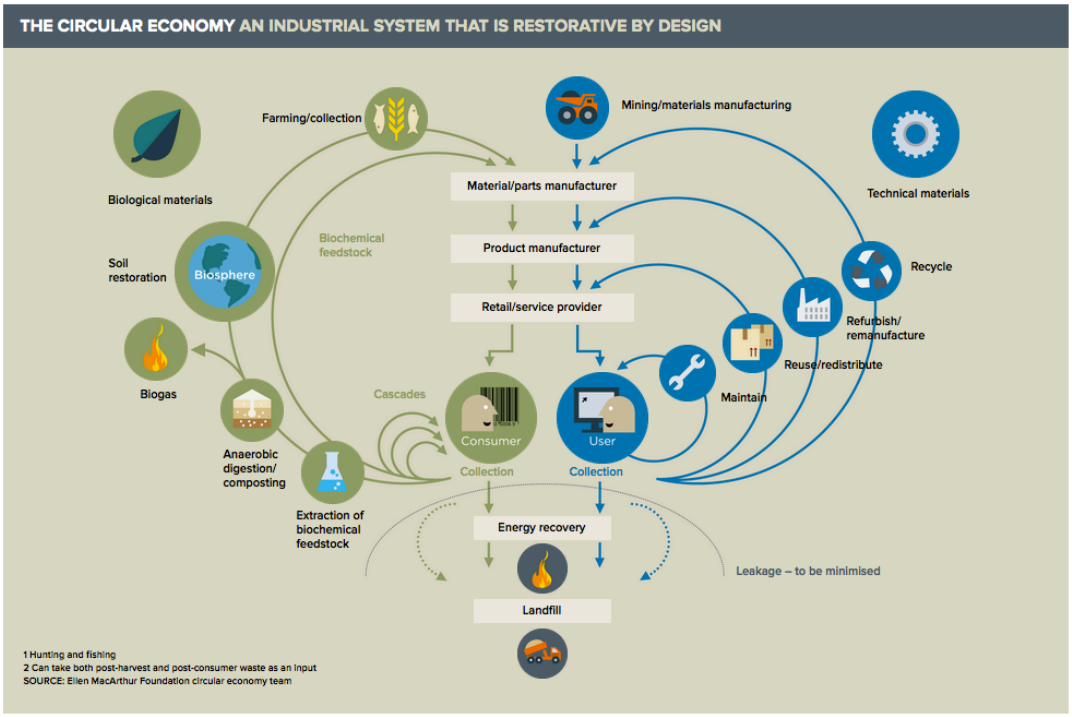


**Figure 1: The Circular Economy diagram.**

From: Ellen MacArthur Foundation (2012a)

Other definitions (such as that carried by ADEME) generally embrace an efficiency approach, a decoupling of economic growth from resources consumption, waste management and a materials stewardship approach. It is generally admitted by many definitions that consumers are transforming into users, enabling new business models such as those highlighted by the Functional Economy literature.

In Circular Economy, value is created using the tightest possible loops for both technical and biotic nutrients. For the technical cycle, the loop with the most value is that of product maintenance and repair, followed by the reuse and redistribution loop, the refurbishing and remanufacturing loop and finally, the recycling loop. For the biotic cycle, biochemical feedstock production is the loop with the most embedded value, followed by renewable energy supply through biogases and finally, agricultural amendment use. Cycling longer, cascading and toxicity reduction are also value creation drivers. It should be noted that all through this literature review, the social dimension has been found mostly lacking in Circular Economy. This is, at best, problematic and should be amended in future development.

**Circular Economy implementation**

Because of its overarching and holistic nature, Circular Economy must be implemented at multiple levels in order to function as intended. Therefore, cooperation between government, civil society and private actors is necessary. While understandable, this condition can also create multi-level obstacles. Some organizations have mapped out steps that various stakeholders can take in order to plan for or circumvent these obstacles, at regional and business levels.

Since the 1990s, several legislations worldwide have conceived of and implemented more or less complex versions of CE. To date, China is the only country that has adopted Circular Economy as a law, in a unique 'harmonious society' perspective, implementing it as large-scale industrial ecology. In Europe, a Circular Economy package was proposed in 2014 but was recently deactivated by the European Commission, in order to prepare a more ambitious and tailor-made package, which should be presented to the members in the course of 2015.

Various elements and business principles have been established in order for companies to adhere to and implement Circular Economy, including business models and disruptive technologies. Circular Economy measurement is also underway in more or less mature states. The Ellen MacArthur Foundation has published its proposed circularity indicators and associated methodology, including a web based tool. The framework is based on a Material Circularity Index (MCI) that focuses on material restoration rate but also proposes complementary material risk indicators. Circle Economy and PGGM's assessment method takes a more holistic point of view based on evaluating at the material, product and system levels. Materials are evaluated against a certain number of factors, which enables product classification. Organizational resource throughput is evaluated against planetary boundaries, economic risk, smart use and ethical allocation. The systemic level of assessment is scored against absolute planetary boundaries and based on value judgment. Impacts are arguably not the focus of both these evaluation frameworks, but other impacts methods, such as LCA, could be complementary.

**Positioning and mapping the concepts**

In order to better analyze and understand Circular Economy and its key associated concepts, a scope and concreteness mapping and a circularity-thinking mapping were designed by the International Life Cycle Chair (ILCC) team of analysts and researchers. They are meant to enable a specific perspective based on various discriminating aspects in order to help position and interpret the various concepts. It should be noted that these positioning mappings were done in the most unbiased way possible, but embed an inevitable proportion of subjective value judgement.

The scope and concreteness mapping uses a matrix composed of a 'y' axis representing application scope and an 'x' axis representing a concreteness gradation. The circularity thinking mapping uses Circular Economy's main principles to evaluate each concept, including a semi-quantitative score, where one star stands for one point. The first mapping is presented at Figure 2 and the second at Table 1.

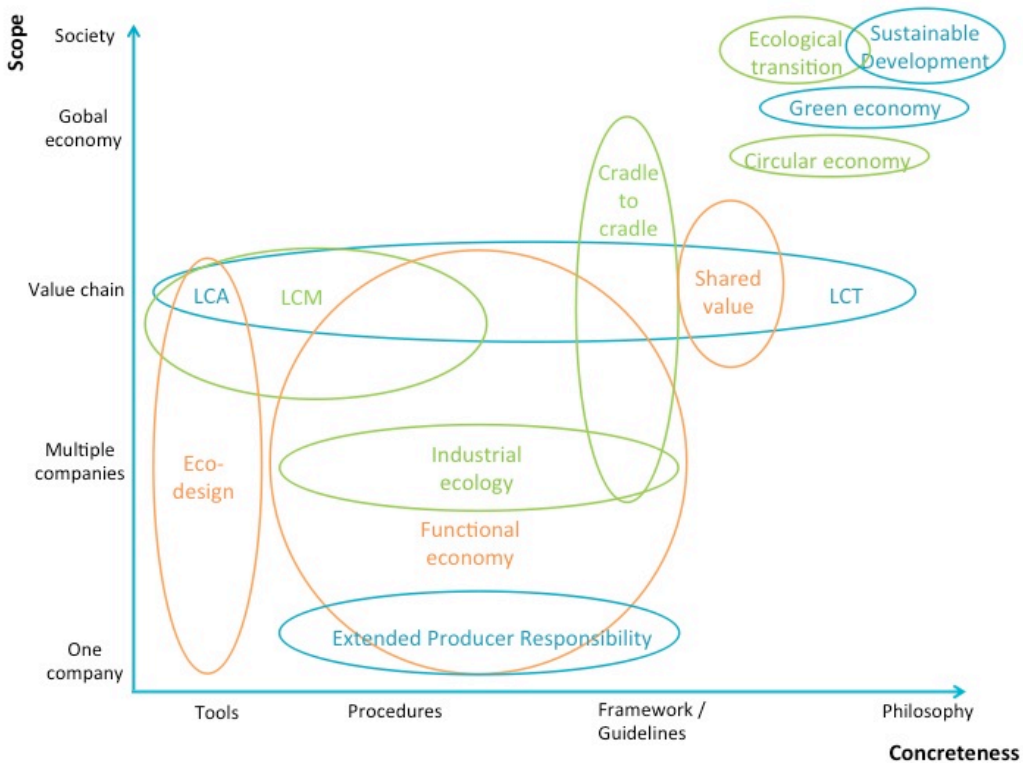


**Figure 2: Scope versus concreteness mapping.**

Note: Colors are used to facilitate the association of an area with its name but do not have a signification.

**Table 1: Circularity thinking mapping based on the pillars underlying the Ellen MacArthur Foundation definition.**

| | Systems thinking | Waste is food | Design out waste | Diversity is strength | Renewable energy | Score |
|---|---|---|---|---|---|---|
| **Sustainable Development** | ★★★ | -- | ★ | ★★ | ★★ | 8 |
| **Ecological Transition** | ★★★ | -- | -- | -- | ★★ | 5 |
| **Green Economy** | -- | -- | -- | -- | ★★ | 2 |
| **Functional Economy** | ★★★ | -- | ★ | ★ | -- | 5 |
| **Life Cycle Thinking** | ★★★ | ★ | -- | -- | -- | 4 |

| | Systems thinking | Waste is food | Design out waste | Diversity is strength | Renewable energy | Score |
|---|---|---|---|---|---|---|
| **Cradle-to-cradle thinking** | ★★★ | ★★★ | ★★★ | ★★★ | ★★★ | 15 |
| **Shared Value** | ★★ | -- | -- | ★★ | -- | 4 |
| **Industrial Ecology** | ★★★ | ★★★ | ★ | ★★★ | -- | 10 |
| **Extended Producer Responsibility** | ★★★ | -- | ★★★ | -- | -- | 6 |
| **Ecodesign** | ★★★ | -- | ★ | -- | -- | 4 |

Legend: Significance of the EC principles for the definition of the associated key concepts
Core: ★★★ ; Present: ★★ ; Marginal:★ ; Absent: --
Score = number of stars

Based on both mappings, it can be said that the examined concepts represent a wide array of scopes, focus and degrees of implementation. Sustainable Development, Ecological Transition, Green Economy and Circular Economy are high-level concepts that show the way towards perennity on the planet in different but largely encompassing ways; they are the goal that must be attained. Ecological Transition, aside from systems thinking and the promise of a focus on renewable energy, does not correspond much to circular thinking. The Green Economy overlaps with Circular Economy in that both concepts leverage economic activities in order to attain sustainability. Green Economy is, however, carried by international organizations, while private actors mostly carry Circular Economy.

Functional Economy is one of the main pillars of Circular Economy and this shows through 1) the fact that it is much more concrete with a scope rooted on individual and grouped organizations, and 2) by its score on the circularity thinking mapping. One of the strongest juncture points is the focus on longevity and intelligent waste-as-input management, powered by innovation and new business models. Life Cycle Thinking (including LCA and LCM) is based on systems thinking, showing on the scope and concreteness matrix that it is a wide (multiple concreteness markers) but shallow (mostly applicable at value chain level) concept. It is steeped in relative sustainability assessment (i.e.: impact assessment based on hotspots identification), while Circular Economy is based on absolute sustainability assessment (ASA); this shows mostly in the circularity thinking mapping, where LCT scores poorly on most circularity thinking principles. Cradle-to-cradle distinguishes itself from all other concepts by its perfect fit with Circular Economy on its most basic principles (as illustrated in the second mapping), while it is evident that its scope, while deep, is counterbalanced by a narrow concreteness range.

Shared Value is a management approach that endeavours to map out the intersection between evaluative approaches and business strategy for profit making; thus its place on the scope and concreteness matrix is precisely at the value chain scope and framework concreteness mark. Its focus on the social/societal dimension does not help shared Value score well on the circularity-thinking mapping. However, both concepts rest on the idea that the economy needs to be overhauled and decoupling

mechanisms need to occur for business and consumers to continue to thrive, although the disruption proposed by Circular Economy is greater than that proposed by Shared Value.

Industrial Ecology is as wide as Functional Economy and Extended Producer Responsibility, but its application scope is based on the association of multiple companies within an industrial eco-system. The concept and applications of Industrial Ecology are based on systems thinking and resource efficiency, thus scoring well within circularity thinking. Extended Product Responsibility is a rather concrete concept which is conceptually applicable to a single company although empirically it is applicable to sectors as well, rendering it as wide as Industrial Ecology and Functional Economy, but much lower on the application scope axis. It can be said to consist of the first attempt at a systematic closed loop system with a private actor focus, helping it to score well for systems thinking and 'design out waste', but does not score at all for other circularity thinking variables. Ecodesign is a tool that aims to implement environmental considerations into product design and is often used in conjunction with LCA, thus generating a deep scope and very concrete range, and unsurprisingly, not scoring strongly on circularity thinking.

**Conclusions and perspectives**

Circular Economy is a multi-level, socio-constructed concept that can either be considered a paradigm shift, a new toolbox, a conceptual umbrella or a portmanteau discipline. It is an idea or concept that is currently being developed, with moving and adaptable content as well as blurred boundaries, feeding from multiple and rich conceptual sources. As a response to resource scarcity and eroding profits, Circular Economy provides an attractive response to a global economic crisis, but manages to leave behind some important issues (such as the social dimension of sustainability).

In short, Circular Economy offers an integrated framework to fuse the triple bottom lines and gives a second wind to useful sustainability concepts as well as providing a strong business vision endorsed by exemplary thought-leaders. Whether it is robust enough to stand the test of multi-level implementation, manages to integrate missing dimensions, is able to properly measure its own progress, enriches current and future sustainability debate are all questions that currently await an answer.

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## Abbreviations and acronyms

| | |
|---|---|
| ADEME | Agence de l'environnement et de la maîtrise de l'énergie (France) |
| BoM | Bill of Materials |
| CE | Circular Economy |
| C2C | Cradle-to-cradle |
| CSR | Corporate Social Responsibility |
| CPP | Consumer Pays Principle |
| DfE | Design for the environment |
| EDDEC | Environnement, développement durable et économie circulaire |
| EEA | European Environment Agency |
| EMF | Ellen MacArthur Foundation |
| EPR | Extended Producer Responsibility |
| EREP | European Resource Efficiency Platform |
| ESG | Environmental, social and governance |
| EU | European Union |
| GDRC | The Global Development Research Center |
| GDP | Gross Domestic Product |
| GRI | Global Reporting Initiative |
| ISIE | International Society for Industrial Ecology |
| ICCE | Implementation Centre for Circular Economy |
| IPAG | Institut de préparation à l'administration et à la gestion |
| IT | Information Technologies |
| LCA | Life Cycle Assessment |
| LCM | Life Cycle Management |
| LCT | Life Cycle Thinking |
| MCI | Material Circularity Indicator |
| MNE | Multinational enterprises |
| NDRC | National Development and Reform Commission |
| OECD | Organisation for Economic Co-operation and Development |
| OEM | Original Equipment Manufacturer |
| O&M | Operations & Maintenance |
| PSS | Product-service system |
| SCP | Sustainable Consumption and Production |
| SEPA | State Environmental Protection Agency |
| SETAC | Society for Environmental Toxicology and Chemistry |
| SD | Sustainable development |
| TNO | The Netherlands Organisation for Applied Scientific Research |
| TTT | Transition Town Totnes |
| UN | United Nations |
| UNEP | United Nations Environment Programme |
| UNEP-SETAC | United Nations Environment Programme and Society of Environmental Toxicology and Chemistry |

| | |
|---|---|
| WCED | World Commission on environment and development |
| WRAP | Waste and Resources Action Program |

# 1 Introduction and a first sketch of the Circular Economy portrait

The global resources crisis that will be upon us in the coming decades has been amply demonstrated, documented and decried. From large consultancy firms, to governments, to NGOs this subject, along with the plea for renewable energy production and the issue of climate change, has generated much literature. Multinational enterprises (MNEs), more than most, are experiencing growing tensions, resources depletion, mounting commodities prices and general supply instability, whether in the environmental or social dimensions.

There is a direct relationship between global gross domestic product (GDP) and resources consumption (Krausmann *et al.*, 2009) marking a coupling of economic development and resources scarcity. It has been estimated that the world population uses 1.5 times the planet's resources yearly (Global Footprint Network, 2015) and everything points towards an acceleration of this trend, as the global middle classes expand (Furness *et al.*, 2012). Apart from recycling efforts, most industries and society's *modus operandi* is generally still based on a linear 'take-make-waste' model. This situation paints a picture in which economic growth based on continued and unabated resources extraction and use, paired with declining innovation disruptions, is doomed to fail.

The previous portrait is generally the one put forward in most Circular Economy literature, in order to position the debate around a need to transition towards an economy that will decouple economic growth from resources depletion. Proposing solutions based on this premise is nothing new and is the core of the Marrakech Process, which encapsulates the idea of Sustainable Consumption and Production (SCP) (UNEP, 2011a). Its origin can be traced back to the Oslo Symposium (1994) when a working definition of SCP was proposed as being:

> *"the use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations"* (Norwegian Ministry for the Environment, 1994).

Yet, proponents of Circular Economy position it as "a whole new way of looking at the world, a political project that can look at the way we manufacture, produce and consume things" (The Forum of Young Global leaders 2015) or as a "challenger" to linear economy, a way to "break the vicious cycle" (Butterworth *et al.*, 2014) and to "create a regenerative, self-organising and sustainable market economy" that would afford "an exciting new way to create value for the firm, by challenging existing industrial paradigms- towards a new strategic direction that's relevant for our changing world" (Raksit, 2014, p.3) based on the "widespread adoption" of "disruptive technologies that allow massive change" (Accenture, 2014). Most also agree that Circular Economy "moves the debate away from efficiency - and on to resource, labour and capital effectiveness" (Butterworth *et al.*, 2014).

The attraction mostly lays in the promise, or hope, of an integrated framework that fuses and reconciles various concepts. The main attractions for business are the quantified savings and various paybacks; the fact that consumers (at least, in certain industrialized countries) are changing and becoming "users" who are less interested in owning but rather in experiencing the service associated with an object; the emergence of new innovation models and so-called breakthrough technologies, able to revolutionize business; and last but not least, the appeal of reconciling together environmental and economic theory through a unified concept that would contain very few trade-offs (Raksit, 2014).

In spite of the new and growing enthusiasm that currently surrounds Circular Economy's ostensive revolutionary potentials, it is generally agreed upon that the idea's conceptual inspirations and precepts

have been around for several decades. As recent environmental history reveals (Renner, 1947; Fischer-Kowalski, 2002), ecosystems' regenerative capacity (or low entropy) has served as a metaphor for a viable economy since at least the 1940s, when the term 'industrial symbiosis' was coined. From such a historical stance, nothing is new to Circular Economy's claim, by which wastes are resources, or food. Similarly, the concepts of 'life cycle assessment' and 'cradle-to-cradle' both began underscoring in the 1970s the critical character of materials and resources circularity to sustainable production and consumption. Yet, when coauthors David W. Pearce and R. Kerry Turner later coined the idea of a Circular Economy (in 1990) through their now famous work "Economics of Natural Resources and the Environment", they neither referred to 'life cycle assessment' or 'cradle-to-cradle'. Moreover still, it appears as though the idea of Circular Economy largely remained unnoticed by the business and management world until roughly 2010, with the birth of the Ellen MacArthur Foundation. Indeed, the inherently descriptive and disciplinary project underlying the original definition of Circular Economy by Pearce and Turner (1990) – which was explicitly intended to fit within the confines of neoclassical economics – had little in common with today's multidisciplinary, vibrant, and apparently transformative appropriations of the notion.

Only by setting today's conception of Circular Economy against such a historical background may we begin to answer these questions, as well as to rigorously situate the numerous concepts in relation to one another. Conceiving of Circular Economy as both a historical and a social construct hence allows us to perceive that the notion – with its meaning and constituents – is far from being a static theoretical idea. As a social construct, it is (and has been) in constant transition and negotiation through time, with its meaning being partly transformed, renewed or frozen as true, under the influence of social actors and changing socio-economic conditions. Conversely, the concept of Circular Economy is influencing social actors, and transforming or reproducing different parts of the world before our eyes.

Taking act of this historically and socially constructed (and hence transitioning) character of the concept, the present report aims at understanding how today's most broadly accepted definitions of Circular Economy either contribute to enriching or to impoverishing the multiple other concepts which it has come to gather and integrate over time, or from which it has historically stemmed. As such, some limits of the trajectory currently being taken may be foreseen as losses in conceptual quality and analytic complexity, which in turn could result in new or repeated forms of social or environmental harm.

Against such a backdrop, how may we understand Circular Economy's recent revival and popularity rise as an overarching, all-encompassing concept? What external circumstances or foreseeable contingencies have converged so as to allow for the notion to be constructed as a credible, robust and operational transition pathway to sustainability? And why now, more than ever before? While these questions beg an answer, the issues addressed in this report are:

- A general portrait of the associated key concepts that underlie Circular Economy, including a conceptual timeline
- What is (or should be) Circular Economy, including definitions, principles, implementation and barriers
- Positioning and mapping of Circular Economy according to scope and concreteness, sustainability approach and circularity thinking

# 2 Circular Economy associated key concepts

This section will explore key concepts that are related to Circular Economy (hereafter named CE). In most cases, these concepts predate CE, as will be shown in the timeline, in section 2.11. Whenever possible, the following aspects will be discussed for each concept:

- Key authors (and/or schools of thought that contributed to the concept's emergence)
- Definition (most accepted definitions and alternate definitions when appropriate)
- Goal (general aim of the concept)
- Application (scale, sector, whether the concept applies to production processes, end-of-life management, etc.)
- Tools

Other key distinctive elements discussed in the literature review will be included in the discussion. Throughout, the goal is to eventually be able to create links between the different concepts, and be able to represent them in relation to CE in a visual diagram. The concepts are treated in descending order of operationalization scope, meaning from vastly encompassing to specific and tactic. A conceptual timeline is presented at section 2.11.

## 2.1 Sustainable Development

Sustainable development (SD) is a polysemic concept that started to be internationally propagated in 1987, after the publication of Gro Harlem Brundtland's Report for the World Commission on Environment and Development (WCED), *Our Common Future*. Its well-known definition also contains two key concepts, which are often not attached to the core definition. These refer to needs, specifically "the essential needs of the world's poor, to which overriding priority should be given". It also broaches the idea of limitations "imposed by the state of technology and social organization on the environment's ability to meet present and future needs"(WCED, 1987).

Even though 1987 marks the emergence of SD, it should be noted that it is preceded by at least 15 years of international efforts to bring forth a certain form of sustainable production and consumption patterns. In 1972, two major events contributed to shape the 1987 definition of SD: the publication of the report to the Club of Rome "Limits to growth" and the Stockholm Conference and Declaration, followed by the World Conservation Strategy in 1980. Post Brundtland, the major events that shaped sustainable development's progress and dissemination are the Rio Summit (1992), which generated its Declaration, Agenda 21 and key international conventions, on climate change and on biological diversity and later, on desertification. The Johannesburg Summit in 2002 brought back the social dimension in the debate as it was neglected in 1992. In 2003, the Marrakech Declaration proposed 5 objectives; two of them are to 1) decouple economic growth from resources consumption and 2) to create a circular economy (Stahel, 2015). In 2012 the Rio+20 summit pressed countries to develop sustainability indicators and put forward the concept of green economy.

The term SD itself starts appearing in scientific publications in the beginning of the 1980s. Since the Brundtland Report, the term has progressively entered the business vocabulary and its practices. The concepts that support SD generally refer to the three dimensions of development (economic - environmental - social) and later, to the triple bottom line, a concept put forth by John Elkington (1997).

Private companies who consider that their responsibilities extend further than profit creation or legally binding constraints adhere to initiatives that can be broadly categorized as Corporate Social

Responsibility (CSR), also a wide field of knowledge and practice. SD and CSR have enabled the creation of thousands of evaluative or normative approaches, initiatives and tools. As examples, thousands of organizations now use the Global Reporting Initiative's (GRI) indicators as a means to present their CSR reports, each year. Many large pension funds now look closely at environmental, social and governance (ESG) indexes before investing. Certifiable or not, many programs such as ISO 26000 or SA8000 have proliferated in the last decade.

On the scientific side, a plethora of authors have written extensively about SD since 1987. In fact, over 200 definitions of SD exist (Pearce and Walrath, 2008). It is therefore more useful to discuss SD conceptually, in order to peg its main tenets against those underlying CE.

The conceptualization of SD can be represented using models, which delineate the considered dimensions as well as their interrelations.

- Jacobs and Sadler (1990), a model in which the 3 dimensions are equal


**Figure 2-1: Sustainable development according to Jacobs and Sadler.**

From: Jacobs and Sadler (1990)

- Passet (1997), in which there are 4 dimensions subordinated to each other

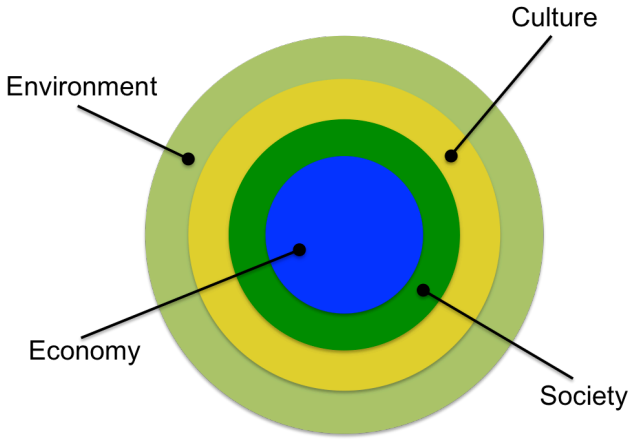



**Figure 2-2: Sustainable development according to Passet.**

From: Passet (1997)

- Gendron (2005), in which 5 dimensions are hierarchized

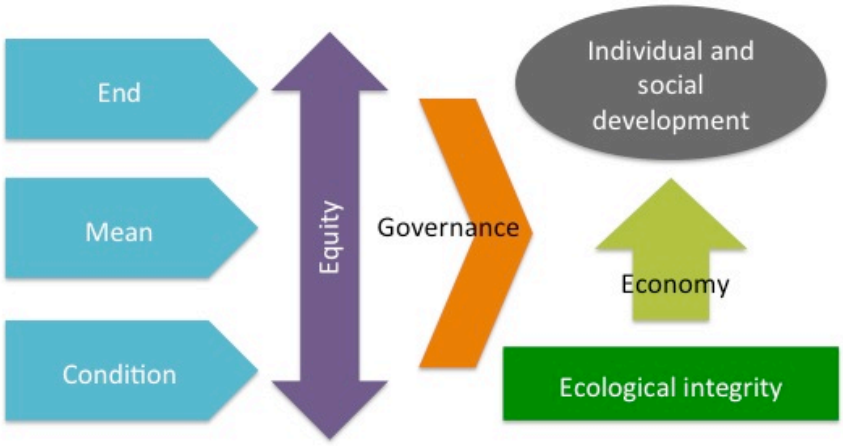



**Figure 2-3: Sustainable development according to Gendron.**

From: Gendron (2005)

## 2.2 Ecological Transition

The core of the "Ecological Transition" concept is "transition", i.e. a transformation process towards a more sustainable societal model. It can take various names according to its focus, such as "sustainability transition", "transition towards a low carbon economy", "socio-ecological transition", etc. The concept is currently mainly used in Europe and is multidimensional: it can be an implementation, a discourse and a theoretical field (Audet, 2015):

- **Implementation:** it can take various forms. A well-known one is the "transition towns" movement, initiated by Rob Hopkins in the 2000s, through which local initiatives aim to build resilient communities with projects on local energy production, food systems, transportation, etc. This implementation has a strong focus on citizen empowerment but this is not *per se* a feature of "ecological transition". Eco-design for instance can also be seen as an implementation of the concept. It can also be applied through public policies targeting ecological tax reforms, amongst other things.
- **Discourse:** "transition" is more and more present in discourses from a wide range of stakeholders from the civil society, companies and governments. The discourse is very variable itself, notably according to its focus on technological versus social innovation.
- **Theoretical field:** this field is still young and in construction. Three main schools of thoughts coexist and offer complementary – though sometimes conflicting – visions. They can be very briefly explained as follows:
    - Reflexive governance: Focuses on the type of governance necessary to manage environmental issues, which are in essence very complex.
    - Multi-level perspective: Studies how socio-technical regimes (e.g. transport regime, agro-food regime) evolve with or resist innovation.
    - Transition management: Explores how to guide transition processes.

As can be seen, "ecological transition" is a polymorph and wide concept. Many visions and initiatives can fall under the concept, some being more techno-centrist and others more socio-centrist, for instance.

There is not one common view about the role of "humans" as beneficiaries and as actors of the transition processes, nor as of the role of economic actors and of innovation.

The term Ecological Transition is also used since 2012 by the French government as a name for their multi-stakeholders process towards a sustainable economic development. In this French context, Ecological Transition is an overall multi-party process gathering all major sustainable development actors and aiming at finding concrete ways to achieve an economic development compatible with the finite character of our natural resources and the necessity to maintain natural regulations essential to life (Dron *et al.*, 2013).

## 2.3 Green economy

The concept of Green Economy has emerged in recent years as a strategic priority for governments and intergovernmental organizations: EU, UN, OECD and others have issued studies, positions papers and strategic plans to achieve this goal (EEA, 2015).

The UN's definition is that Green Economy is an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive (UNEP, 2011b).

The concept of Green Economy puts forth the use of economic instruments to tackle environmental challenges: e.g. initiatives allowing the internalization of environmental costs (e.g. carbon market), investments in green technologies or renewable energy.

Green Economy was one of the main discussion fields at the RIO+20 Conference in 2012. The resolution adopted by the General Assembly at the end of the conference, called *The future we want*, states:

> *"(…) we consider green economy in the context of sustainable development and poverty eradication as one of the important tools available for achieving sustainable development and that it could provide options for policymaking but should not be a rigid set of rules. We emphasize that it should contribute to eradicating poverty as well as sustained economic growth, enhancing social inclusion, improving human welfare and creating opportunities for employment and decent work for all, while maintaining the healthy functioning of the Earth's ecosystems"* (UN General Assembly, 2012).

A focus hence lies on developing Green Economy policies encouraging the emergence of conditions favourable to green economy projects, initiatives or models.

An important strategic approach to achieve Green Economy is "decoupling". Decoupling can be simply defined as breaking the link between "environmental bads" and "economic goods". Two modes of decoupling need to be undertaken: resource decoupling and impact decoupling (UNEP DTIE, 2011).

An important criticism of Green Economy is that it can potentially make the social pillar of sustainable development disappear as international efforts tend to be redirected towards this concept, which has economic actors and activities at its core. The dominant place of Green Economy on the Rio+20 agenda at the expense of sustainable development at large is an illustration of this fear: even if Green Economy does not aim to replace sustainable development, it becomes *de facto* a "weaker" version of sustainability ambitions.

## 2.4 Functional Economy

The main pioneer of Functional[1] or Performance Economy, Walter R. Stahel, coined the term in 1986. Succinctly, Functional Economy is focused on the function, or performance, of goods and services. Stahel considers it a new business model with enterprises retaining ownership of long life-span goods combined with lower energy and materials demand for the production phase, made possible by (amongst other thing) appropriate design (Indigo Development, 2005; Stahel, 2013b). It is considered by some as the most profitable business models of all for CE (Butterworth *et al.*, 2014).

The term Functional Economy relates to the co-production of integrated solutions for products and services that meet households (B to C) and industry (B to B) expectations between providers and beneficiaries, consolidating new environmental and social requirements (Gaglio *et al.*, 2011). Du Tertre posits that the most specific aspect of Functional Economy is the design and implementation of these integrated solutions, which will provoke a change at a systemic level, and support triple bottom line issues in an articulated manner. For example, it is a question of moving from "the automobile" or "public transportation" to the concept of "mobility" (ATEMIS, 2008).

Functional Economy assumes that efficiency and effectiveness must be reconciled, as it changes the role of actors in an economy where long life span and performance mean that "doing the right thing" (or: effectiveness) must be paired with "doing them right" (or: efficiency). The main goals of Functional Economy are:

- Increase in wealth creation
- Jobs increase[2]
- Reduction of resources consumption (Stahel, 2010).

A looped economy is at the core of Functional Economy, as waste prevention, refurbishment and reconditioning (as well as extended consumer insurance) are integral to long life-span and retained ownership (Stahel, 2015). Stahel is a core proponent of CE but also posits that linear economy is complimentary to CE, as it contributes to what he calls 'quantum leap innovation' in sectors such as IT, nanotechnologies and biotechnologies (Stahel, 2015). This view is somewhat paradoxical to what most CE proponents say, namely that linear economy is currently unable to produce additional disruptive technologies. The business models of Functional or Performance Economy are presented in Figure 2-4.

[1] Also sometimes called the Functional Service Economy or Service Economy. Its key associated operational concept is product-service system (PSS). It is defined as "a marketable set of products and services capable of jointly fulfilling a user's need. The product/service ratio in this set can vary, either in terms of function fulfilment or economic value" (Goedkoop *et al*., 1999 in Mont, 2002).

[2] It should be noted that Functional or Performance Economy is one of two concepts (the other being Shared Value), which includes a social vision to its core elements. Stahel and Reday (1976) proposed to (what is now called) the European Commission a report (*The Potential for Substituting Manpower for Energy*) that the creation of local jobs (linked to e.g., refurbishment, waste management, etc.) based on a vision of care for people as part of an integrated "stock" management approach, which would "exploit" stock while maintaining its quality and value.

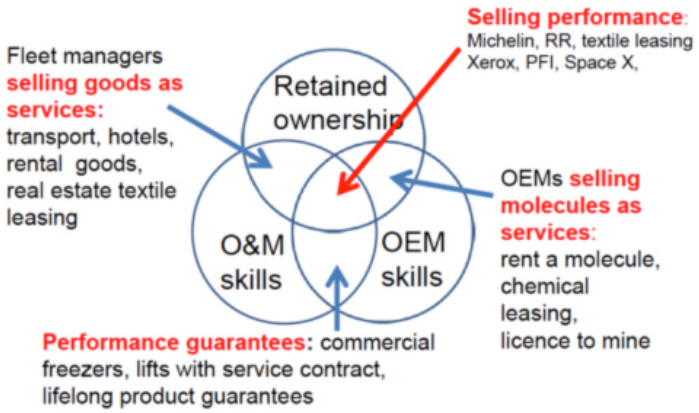



**Figure 2-4: The Business Models of Performance or Functional Economy.**

From: Stahel (2015), p. 21

Longer lifespan of products means that the quality of maintenance, repair, refurbishment and/or remanufacturing is a key component of the business model, as is value preservation through the transformation of waste into new products in order to maximize revenue and minimize internalization costs (Stahel, 2015).

In a Functional Economy, governments must implement the taxing of non-renewable resources, as opposed to taxing labour, and abandon the command-and-control type policies in order to instead promote innovation, education, R&D and appropriate entrepreneurial risk taking. As well, tax incentives must be designed in order to reward companies who internalize risks over the whole life cycle (Stahel, 2010), thus creating a link with the concept of Extended Producer Responsibility.

The metrics proposed by Stahel (2010) theoretically allow all stakeholders (consumers, countries and private economic actors) to evaluate products, production units, corporations or regions' performance (Stahel, 2010). They are:

- Value-per-weight, which enables growth and wealth creation using minimal resources
- Profits based on risks and waste internalization over goods' entire service-life, to transfer performance and quality responsibility, over the full service life, from the user to the producer
- Labour-input-per-weight, which enables local jobs creation using minimal non-renewable resources (principle of manpower for energy)

It is interesting to note that the usual metrics proposed by traditional industrial models are based on resource throughput monetization at the point of sale, namely: gross national product (at country level) and annual sales (at company level) (Stahel, 2010). Functional Economy's metrics are illustrated in Figure 2-5.

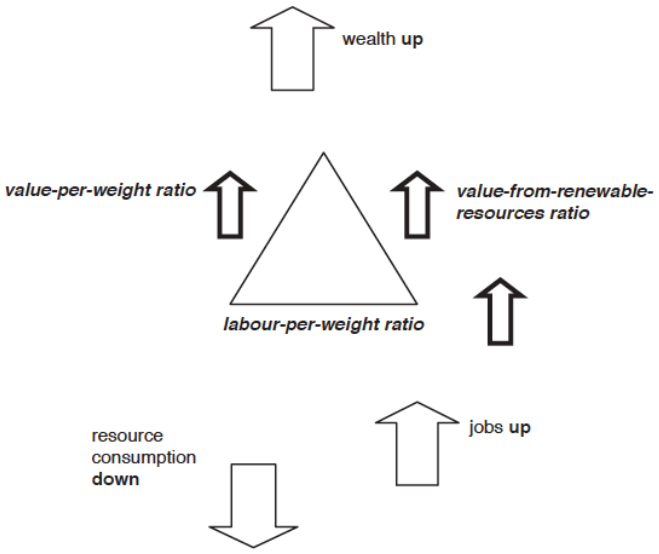



**Figure 2-5: Graphic presentation of metrics.**

From: Stahel (2010), p. 4

Stahel's vision of Functional Economy ties closely with SD, as it aims to provide tools to attain at least two of the Marrakech objectives (as mentioned in section 2.1: to decouple economic growth from resources consumption and to create a circular economy). Figure 2-6 illustrates the Performance Economy's sustainability triangle.

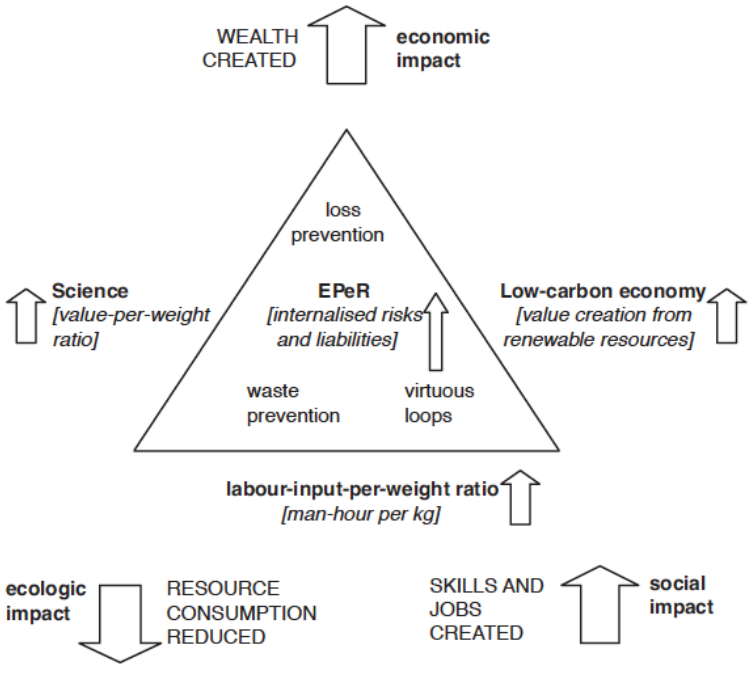



**Figure 2-6: The Performance Economy's sustainability triangle.**

From: Stahel (2010), p. 272

Functional Economy has also been associated with dematerialization and with the consumer movement known as the Share Economy[3], an economy based on sharing goods rather than owning them, made possible through IT based business models which enable consumers/users to connect and buy or share products and services (e.g.: Airbnb and Uber).

## 2.5 Life Cycle Thinking

The main initial observation that led to Life Cycle Thinking (LCT) is that looking for environmental optimization within one organization does not guarantee an optimized value chain, and can even lead to impact displacement from the organization to another part of the product chain. It is therefore necessary to adopt a holistic perspective in order to reach total environmental optimization throughout the product's life cycle.

As shown on Figure 2-7, a product or service's life cycle goes from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling.

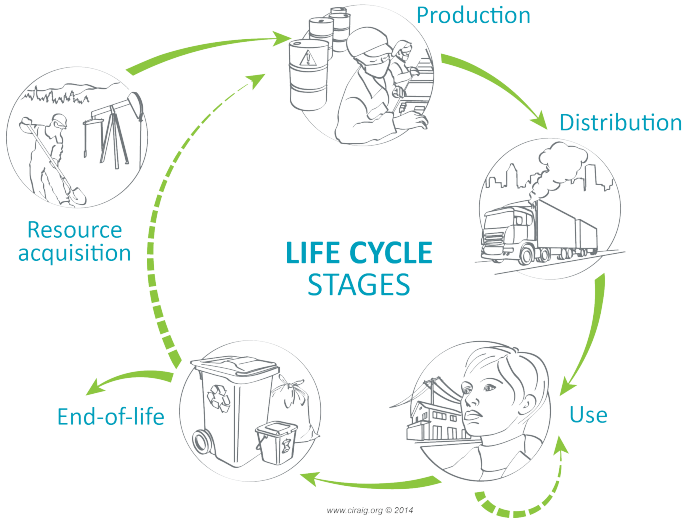



**Figure 2-7: Life cycle stages.**

From: CIRAIG (2015)

The most well known way of applying LCT is environmental Life Cycle Assessment (LCA), which started in the years 1960s, as partial LCAs. Guinee *et al.* (2010) split the development of LCA in three main stages: 1) Conception (1970-1990); 2) Standardization (1990-2000); 3) Elaboration (2000-present).

LCA is a methodological tool used to quantify the potential environmental impacts associated with the entire life cycle of a product. Heiskanen (2002) proposed that LCA has evolved from being purely a

[3] The Share Economy is also known as the Collaborative Economy and also, on consumer side, as Collaborative Consumption, a term coined by Rachel Botsman around 2010.

calculation method to a state of mind, looking for understanding the life cycle-related issues of the product, away from the focus on individual performance. This state of mind is called "Life Cycle Thinking".

The main goals of environmental LCT are to reduce environmental impacts throughout the products' life cycles, thanks to the reduction of resource and energy use and of emissions to air, water and soil (Life Cycle Initiative, 2013). LCA is seen as the most complete tool to **assess eco-efficiency**, i.e. "adding maximum value with minimum resource use and minimum pollution"(Huesemann, 2004 in Bjørn and Hauschild, 2013, p. 322). Economic and social dimensions were added to the LCT tools' portfolio, in order to enlarge the scope and enable an even more holistic perspective.

The term "Life Cycle Management" also appeared as the way to apply LCT in organizations or, as put by the UNEP-SETAC (2009, p.vii), as "a business management approach that can be used by all types of businesses (and other organizations) to improve their products and thus the sustainability performance of the companies and associated value chains". LCM is also defined as a box containing the tools aiming to measure and manage potential environmental, social and economic impacts of products or services throughout their life cycle. LCM contains a wide variety of tools such as LCA, ecodesign, eco-labelling, social LCA, etc.

Environmental and social LCA's guidelines have been negotiated, designed and formalized through ISO norms development and through the UNEP-SETAC Life Cycle Initiative working groups. In the last 5 years, a conceptual framework for Sustainability Life Cycle Assessment has also been published by UNEP-SETAC.

An interesting study by Nilsson-Lindén *et al.* (2014) investigates how LCM is put in practice in organizations. Among their findings and those from consulted authors, we underline:

- Companies will implement and use LCA in different ways. These differences not only arise from structural differences but also from how people interpret and make sense of LCA results. Organizational context and individual sense-making affect how LCA is used in industry (Rex and Baumann, 2008 in Nilsson-Lindén *et al.*, 2014).
- Pure LCA facts are not always the most valuable outcomes of an LCA project. Improved understanding of 1) internal processes and 2) the concerns of the other actors in the value chain are essential outcomes (Poikkimäki, 2006 in Nilsson-Lindén *et al.*, 2014).
- When the time comes for implementing environmentally favourable developments, intangible aspects (e.g., how people perceive, understand, and value things) have more influence than rational justifications (e.g. LCA facts) (Poikkimäki, 2006 in Nilsson-Lindén *et al.*, 2014).
- As LCM focuses on the product chain, collaboration with external actors and the need to build relationships are identified as a critical success factor.
- Internal critical success factors: Top management support, sound internal communication, participation and collaboration of employees from most organizational functions and levels, integration of sustainability into the organization's business strategy.

## 2.6 Cradle-to-cradle thinking

Cradle-to-cradle[4] (termed "C2C" from henceforth) thinking is acknowledged to be at the heart of CE's closed loop systems. It is a nature-inspired, biomimetic design philosophy formalized by Michael Braungart and William McDonough, first encapsulated in the book *Cradle-to-cradle: remaking the way we make things* (2002). C2C aims to create products with a positive environmental footprint (Bor *et al*., 2011). Most of CE's distinctive vocabulary is taken directly from C2C: biological and technical nutrients, metabolism, upcycling, etc. (Bor *et al*., 2011).

Its origins can be traced back to the 1990s, when Braungart and some Environment Protection Encouragement Agency (EPEA) colleagues published *A Technical Framework for Life-Cycle Assessment* (Visser, 2010). While this publication can effectively trace back the C2C idea to LCA, C2C however distances itself wholly from LCA (inherently linear, according to the authors), as its main tenet is that it is essential to move from eco-efficiency to eco-effectiveness. For Braungart and McDonough, eco-efficiency basically corresponds to make more (products or services) with less (resources, energy, toxicity). The authors affirm strongly that:

> *"1. Eco-efficiency is a reactionary approach that does not address the need for fundamental redesign of industrial material flows.*
>
> *2. Eco-efficiency is inherently at odds with long-term economic growth and innovation*
>
> *3. Eco-efficiency does not effectively address the issue of toxicity."* (Braungart *et al.*, 2007, p.1339-1340)

In contrast, eco-effectiveness "encompasses a set of strategies for generating healthy, cradle-to-cradle material flow metabolisms" (Braungart *et al.*, 2007, p.1342). Eco-effectiveness is then a mechanism that recouples environmental and economic systems through 'metabolisms' that enable materials to maintain and even augment their inherent characteristics through upcyciling. Instead of improving existing products, eco-effectiveness as underscored by Braungart *et al.* (2007) (re)develops products from the ground up by redesigning material flows, addressing toxicity and eliminating all possible economic growth and innovation shortcomings inherent to eco-efficiency. They however convene the fact that eco-efficiency and eco-effectiveness can be complimentary, as "doing the right thing" (eco-effectiveness) should be "doing things right" (eco-efficiency). They underline the fact that trimming material flows is only beneficial if they have been previously "closed", as "once effectiveness has been achieved, efficiency improvements are not an environmental necessity, but a matter of equity. They are necessary to ensure the fair distribution of goods and services"(Braungart *et al.*, 2007, p.1342). Figure 2-8 presents Braungart *et al.*'s view of the eco-effective and eco-efficient time/benefit curves.

[4] Cradle-to-cradle is also known as cradle 2 cradle and regenerative design.

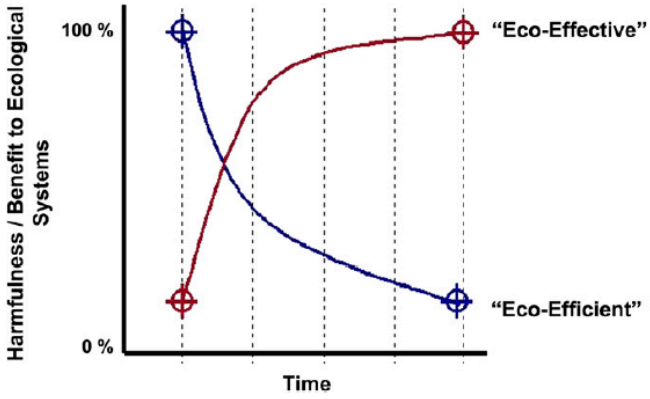



**Figure 2-8: Eco-effectiveness strives to generate an entirely (100%) beneficial impact upon ecological systems.**

From: Braungart *et al.* (2007), p. 1343

C2C's materials (or nutrients) flow within one of two metabolisms: biological and technical. Materials that flow optimally through the biological metabolism are called biological nutrients. Biological nutrients are basically consumption products, while technical nutrients are used for durable goods that are used as a service (thus making the link with Functional Economy) and should have characteristics that allow them to remain safely in the closed-loop C2C system. Eco-effective industrials parks (basically, Industrial Ecology through industrial symbiosis) are created in order for these nutrients to flow effortlessly within a broad industrial framework.

C2C is a mostly qualitative innovation framework, which promotes three guiding principles:

1) 'Waste = food', in the sense that what is usually considered waste and by-products should act as nutrients within the metabolic system.
2) Current solar income powers products' energy requirements, including geothermal and kinetic energy.
3) Diversity, whether biological, cultural or conceptual, must be celebrated (Bor *et al.*, 2011).

C2C can be achieved by enterprises through a 5 steps strategy:

1. Removal of toxic substances in products
2. Render the product "less bad" through personal preferences
3. Passive positive list: ingredients assessment according to toxicological or eco-toxicological characteristics
4. Active positive list: ingredient optimization (from previous list) in order for them to be defined as a biological or technical nutrient.
5. Reinvention of customer-product relationship through a service perspective

Nutrients flow management can only occur within collaborative business and industrial structures that enable information and material flows through the products' life cycle, taking the shape of either what is basically industrial symbiosis or Intelligent Material Pooling (IMP). IMP is presented at Figure 2-9.

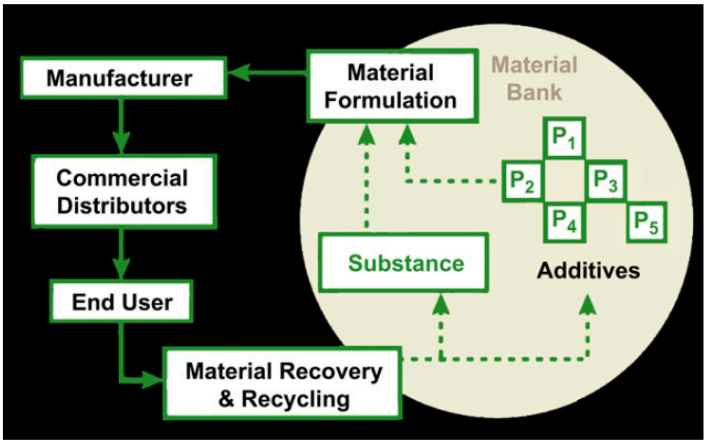



**Figure 2-9: Material flows in the context of an Intelligent Materials Pooling community.**

From: Braungart *et al.* (2007), p. 1347

IMP is a technical nutrient metabolism collaboration system between economic actors that allows enterprises to "pool material resources, specialized knowledge and purchasing power relating to the acquisition, transformation and sale of technical nutrients and their associated products" resulting in a symbiotic, mutually beneficial system (Braungart *et al.*, 2007, p.1346)

It should be noted that C2C as well as Cradle-to-cradle are registered trademarks of Braungart and McDonough's consultancy, MBDC, and may only be used under license. As well, the Cradle-to-cradle Certified mark for products may only be used by the Cradle-to-cradle Products Innovation Institute (MBDC, 2012). This situation points to the hypothesis that a strong association between the EMF and the C2C approach, contrary to other concepts presented here, may mean that there are high economic stakes in CE's successful implementation for C2C proponents.

## 2.7 Shared Value

Shared Value is a management approach put forward by Harvard Business School professors and strategy authorities Michael E. Porter and Mark R. Kramer. The idea was first introduced in 2011 in an article called "Creating Shared Value". Its focus is on "creating measurable business value by identifying and addressing social problems that intersect with their business" (Shared Value, 2015). According to Porter and Kramer (2011), the central idea of creating shared value is that "what is good for society is also good for business". The authors share a point of view that "narrow-minded" capitalism has failed to answer societal demands and that a new conception of capitalism, propelled by Shared Value, is necessary. Thus, the Shared Value framework creates new opportunities for companies, civil society organizations, and governments to leverage the power of market-based competition in addressing social problems.

The framework proposes to establish a strong link between market competitiveness and socio-economic progress for the communities in which a given company operates. Value creation is "shared" by private companies because it focuses on identifying and expanding strong links between social progress and profits. Porter and Kramer also mention the need to transform 'vicious' organizational cycles (the so-called "poisoned fruit of capitalism", in regard to social progress) into 'virtuous' cycles. To do this, they propose to re-legitimize the concept of private companies (one could even say: their business model) using three modes of operationalization:

1) **Redesigning products and markets:** this implies that companies must uncover unmet social needs or problems that need addressing, and then create products to meet the need or solve the problem.
2) **Redefining the value chain:** behind this idea is the search for better productivity by responsibly addressing environmental or social/societal issues.
3) **Creating local community development clusters:** multinationals who establish their production units in communities all over the world must enable community resilience and success in order to enhance competitiveness (Porter and Kramer, 2011).

Innovation is then no longer bound to simply capture unrealized technological value creation or develop new revenue architecture, but is rather steeped in the satisfaction of a social need (e.g., access to clean water, decent housing, etc.). The authors believe that the Shared Value approach will foster the next wave of innovation, as well as the growth of the global economy (Porter and Kramer, 2011). The approach distances itself from CSR and philanthropy, as well as from stakeholder engagement processes.

Shared Value must also be measured against the three operationalization modes, as illustrated in Table 2-1.

**Table 2-1: Illustrative Business and Social Results by Level of Shared Value**

| LEVELS OF SHARED VALUE | BUSINESS RESULTS | SOCIAL RESULTS |
|---|---|---|
| **Reconceiving product and markets:**<br>How targeting unmet needs drives incremental revenue and profits | • Increased revenue<br>• Increased market share<br>• Increased market growth<br>• Improved profitability | • Improved patient care<br>• Reduced carbon footprint<br>• Improved nutrition<br>• Improved education |
| **Redefining productivity in the value chain:**<br>How better management of internal operations increases productivity and reduces risks | • Improved productivity<br>• Reduced logistical and operating costs<br>• Secured supply<br>• Improved quality<br>• Improved profitability | • Reduced energy use<br>• Reduced water use<br>• Reduced raw materials<br>• Improved job skills<br>• Improved employee incomes |
| **Enabling cluster development:**<br>How changing societal conditions outside the company unleashes new growth and productivity gains | • Reduced costs<br>• Secured supply<br>• Improved distribution infrastructure<br>• Improved workforce access<br>• Improved profitability | • Improved education<br>• Increased job creation<br>• Improved health<br>• Improved incomes |

From: Porter *et al.* (2011), p. 3

It is suggested that measurement be an integrated part of business strategy, and be implemented in an iterative fashion, creating a feedback loop that permits continuous improvement (as illustrated in Figure 2-10).

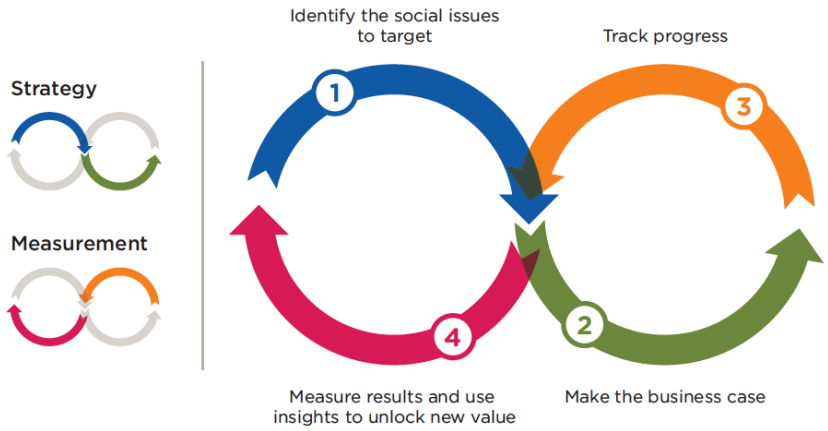



**Figure 2-10: Integrating Shared Value Strategy and Measurement.**

From: Porter *et al.* (2011), p. 2

The measurement process encompasses 4 steps:

1. **Identification of social issues:** this step is basically a search and screening process used to identify unmet social needs and problems and evaluate their overlap with the organizations services or products, as they pertain to the three operationalization modes. It results in a list of social issues to prioritize in order to create a Shared Value strategy.
2. **Creation of a business case:** this step consists in analysing the social needs opportunities against the business performance possibilities through identifying targets and activities involved in a modelization of potential business and social results. This step defines if a Shared Value initiative goes forward or not.
3. **Progress tracking:** this step consists in tracking targets, activities, inputs and outputs against the business case blueprint.
4. **Results measurement and operationalization:** this fourth step serves to evaluate business and social results against what was anticipated at the beginning. It also serves as input for strategy refinement or change of direction in its execution.

Further, it has been suggested that Shared Value social innovation should correspond to 5 reinforcing strategic ingredients (Shared Value Initiative, 2014), as illustrated in Figure 2-11:

- Purpose
- Defined need
- Shared Value measurement
- Co-creation of Shared Value
- Innovation structure

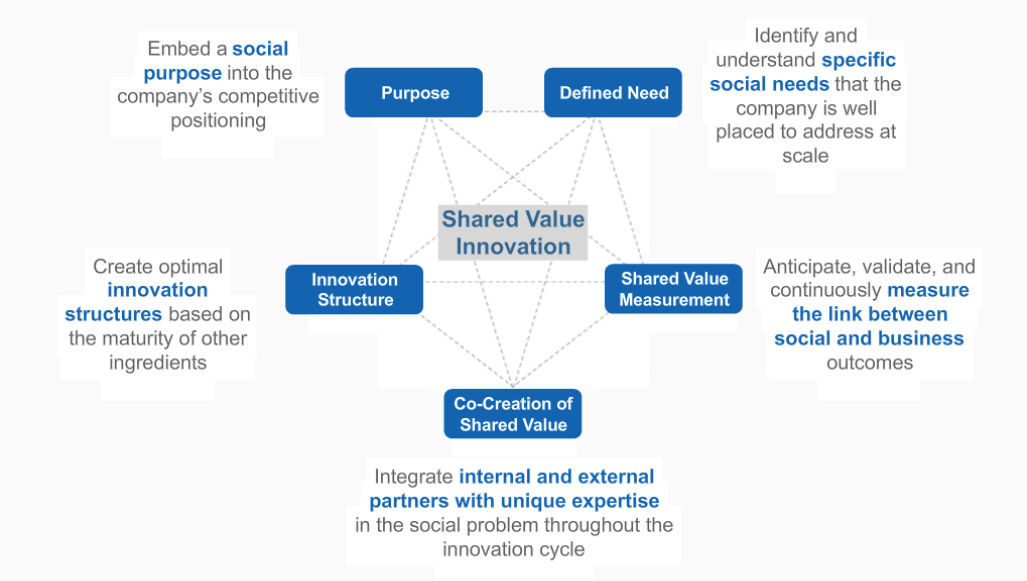



**Figure 2-11: The 5 reinforcing ingredients of Shared Value innovation.**

From: Shared Value Initiative (2014)

## 2.8 Industrial Ecology

Although ideas regarding Industrial Ecology exist since at least the 1940s, the official birth of the "industrial ecology" concept can be related to a 1989 scientific article by Robert Frosch and Nicholas Gallopoulos that suggested the need for "an industrial ecosystem" in which "the use of energies and materials is optimized, wastes and pollution are minimized, and there is an economically viable role for every product of a manufacturing process" (ISIE, 2015). A concrete demonstration of this concept started in 1972 in Denmark, in the municipality of Kalundborg and is still ongoing, with 9 industries among which the municipality itself (ADEME, 2013).

Industrial Ecology asks us to "understand how the industrial system works, how it is regulated, and its interaction with the biosphere; then, on the basis of what we know about ecosystems, to determine how it could be restructured to make it compatible with the way natural ecosystems function" (Erkman, 1997 in ISIE, 2015) (Erkman, 1997 in ISIE, 2015). The idea is, then, that industry can be seen as a "man-made ecosystem that operates in a similar way to natural ecosystems, where the waste or by product of one process is used as an input into another process" (GDRC, 2015). The goal is to have industries work together in order to move from a linear to cyclical or closed loop system (GDRC, 2015).

There is not one clear definition of Industrial Ecology. For Erkman however, it is important to note that it is a conceptual framework as well as an implementation tool. The author also states that "industrial ecology does not address just issues of pollution and environment, but considers as equally important, technologies, process economics, inter-relationships of businesses, financing, overall Government policy and the entire spectrum of issues that are involved in the management of commercial enterprises" (Erkman, 2001, p. 3). One application of this concept is called industrial symbiosis, which is "an association between two or more industrial facilities or companies in which the wastes or by-products of one become the raw materials for another" (WRAP, 2014).

Regarding scale, Industrial Ecology is mostly applied at the local level, with physical proximity among partnering companies. However, the International Society for Industrial Ecology (ISIE) says that

Industrial Ecology "examines local, regional and global uses and flows of materials and energy in products, processes, industrial sectors and economies" (ISIE, 2015).

It is easier to apply the concept to new industrial zones in order to maximize potential synergies between companies but it is also feasible in existing zones, necessitating flows inventories and developments of partnerships (Geldron, 2013).

## 2.9 Extended Producer Responsibility

Extended Producer Responsibility (EPR), like other concepts, bears multiple definitions mobilized by various stakeholders. At least two largely cited definitions emanating from robust sources exist. The first originates from Thomas Lindhqvist (1992), who introduced the concept in Sweden in 1990 and is considered one of the main originators of the EPR concept:

> *"[EPR] is an environmental protection strategy to reach an environmental objective of a decreased total environmental impact of a product, by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal"* (Lindhqvist, 2000, p. ii).

The second, and most well-known and used definition, is the one put forward by the OECD in the early 2000s:

> *"an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle. There are two related features of EPR policy: (1) the shifting of responsibility (physically and/or economically; fully or partially) upstream toward the producer and away from municipalities, and (2) to provide incentives to producers to incorporate environmental considerations in the design of their products"* (OECD, 2015).

Both definitions underline the importance of the end-of-life stage, but Lindhqvist insists on the full life cycle responsibility being of great importance in global environmental impacts reduction. The OECD's literature is based on policy and incentives design, with a large focus on end-of-life systems, sometimes to the detriment of the full life cycle responsibility. These two postures (whole life cycle vs. focus on end-of-life) are also present in the general scientific literature on the subject of EPR.

EPR is consistent with the principle of 'polluter pays' and is necessary in order to reflect life cycle costs in a product's price (Lindhqvist, 2000). As a model, EPR may be understood as encompassing the following variables, illustrated in Figure 2-12: liability, ownership, economic responsibility, physical responsibility and informative responsibility.

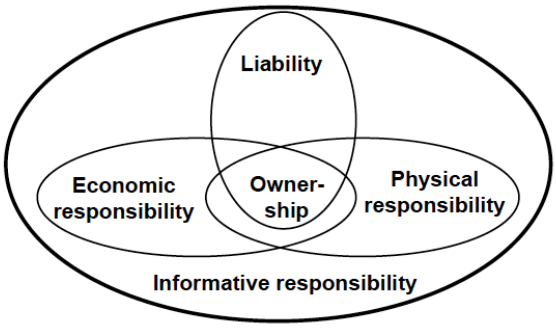



**Figure 2-12: Models for Extended Producer Responsibility.**

From: Lindhqvist (2000), p. iii

Environmental damages are linked to liability, which is determined by local legislation. Economic and physical responsibilities are the variables used to determine, respectively, the expenses incurred and the physical management systems. Retained product ownership will mean that the producer is liable for the entire life cycle and for the full physical and economic responsibility. Informative responsibility means that producers must supply the appropriate environmental information about their products to consumers (Lindhqvist, 2000).

Various instruments are used within an EPR initiative, such as take-back schemes, advanced disposal fees, deposit-refund, a combination of upstream tax and downstream subsidy, and standards (OECD, 2015). These instruments are still much used today, eloquently illustrating how EPR's focus has shifted almost exclusively to end-of-life management since the beginning of the 1990s. Some authors challenge this focus on a conceptual level, positing that EPR should in fact encompass materials choice and reduction of toxicity thus creating a strong link and an incentive for ecodesign (Lifset *et al.*, 2013).

Within an EPR initiative, producers should benefit from incentives to design or redesign their products in order to not only reduce environmental costs and impacts over the entire life cycle but also reduce resources use, enable or enhance reusability and recyclability (OECD, 2015). While theoretically, ecodesign should be the tool of excellence to reduce inherent EPR costs upstream, in reality EPR has had little influence on the actual design or redesign of products (Dempsey *et al.*, 2010 in Lifset *et al.*, 2013). So while EPR may have the potential to achieve some Industrial Ecology goals (e.g.: closing loops), in fact, it has rather generally helped in establishing better postconsumer recycling systems and facilities (Lifset *et al.*, 2013). It is to be noted that EPR is a vivid subject in the Cleaner Production and the Industrial Ecology scientific communities.

## 2.10 Ecodesign

The context for the emergence of ecodesign is based on the same premise as that of CE: that resources are limited and that industry is generally based on a take-make-waste model (or: linear economy). As it is a known fact that over 80% of impacts can be avoided at the design stage, ecodesign is therefore viewed as a way to introduce eco-efficiency and impacts reduction into the design process, from the outset (Knight and Jenkins, 2009).

According to a broadly accepted definition, "ecodesign focuses on the integration of environmental considerations into product development" (Karlsson and Luttropp, 2006 in Bovea and Pérez-Belis, 2012, p. 61). It should be environmentally appropriate, but also take the end user into consideration. Ecodesign is sometimes associated to "design for the environment" (DfE) and also to the reduction of impacts over the entire life cycle. It is however important to draw the line between Ecodesign and sustainable design (or design for sustainability), as Ecodesign does not incorporate social and ethical aspects (Knight and Jenkins, 2009, p.61).

Ecodesign should be implemented not as a specific method, but rather as an analytical thought process, to every appropriate design phase or level, should be based on sound design and engineering processes and knowledge and be integrated with the environmental sciences. In order to generate significant results, Ecodesign needs to be integrated systematically over the whole product development process in a long-term perspective and *in fine*, be a requirement over the whole value chain. This being said, evidence of Ecodesign implementation is not well documented (Knight and Jenkins, 2009). Ecodesign's scope is visually represented by Figure 2-13.

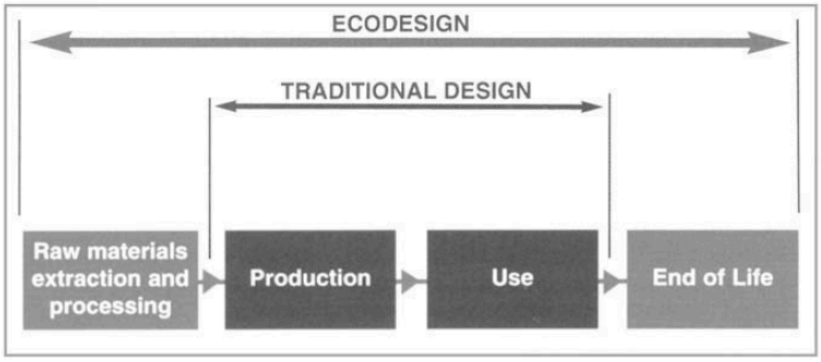



**Figure 2-13: Ecodesign scope.**

From: Knight and Jenkins (2009), p. 550

Ecodesign's main challenges are to respond to customers' needs at the lowest cost (both economic and environmental) and still manage to balance other considerations, namely policy (e.g.: recyclability) engineering, design (e.g.: function, aesthetics, etc.) and business (e.g.: costs, revenue generation, marketing) (Luttropp and Lagerstedt, 2006).

In terms of Ecodesign tools, some authors categorize them according to measurement type, meaning whether they are qualitative or quantitative (Calow *et al*., 2001; Ernzer and Wimmer, 2002; etc.) sometimes adding a semi-qualitative category (Bovea and Pérez-Belis, 2012). Another, perhaps more useful (or at least illustrative) way of categorizing ecodesign tools is according to what they do and how they do it. Luttropp and Lagerstedt (2006) classify them into:

- "Swiss army knife" (or general) tools which combine simplicity with a multipurpose approach and may or may not include guidelines, inspiration and case studies
- Tools with a special focus, either on a specific product (e.g.: a vehicle) or product category (e.g.: electrical and electronic devices)
- Tools that are life cycle based
- Tools that focus on dematerialization strategies

Knight and Jenkins classify ecodesign tools into 3, broader categories:

1. **Guidelines**: have a broad scope, largely applicable but lacking details; can include the whole life cycle or specific product development phases or areas
2. **Checklists**: provide specific and detailed, but narrow, application processes over selected stages of the life cycle or product development process; includes black/grey/white checklists and other types of checklists
3. **Analytical tools**: permit detailed and/or systematic analysis for specific stages of the design process or of the lifecycle; includes eco-indicators, impact assessment, environmental effect analysis, LCA, life cycle costing, MET matrix, etc. (Knight and Jenkins, 2009).

Companies will typically start with guidelines and materials checklists and then move on to more complex and/or specific tools, eventually creating and deploying proprietary tools (Luttropp and Lagerstedt, 2006), as exemplified by Nestlé's EcodEX tool (Schenker *et al.*, 2014).

Appendix A provides a synthetized table containing all key associated concepts as well as their goals, main authors, application scale and tools. A discussion about the previously defined key associated concepts when compared to CE is available at section 4.5.

## 2.11 Concepts timeline

A non-exhaustive timeline of CE's main associated concepts is presented in Table 2-1 as a way to illustrate its historical development in a synthetic way.

**Table 2-2: Circular Economy conceptual timeline**

| Date | Originator | Document (if applicable) | Key concept(s) |
|---|---|---|---|
| **1890** | Alfred Marshall | Book: *Principles of Economics* | **Marshall coins the term "Industrial districts"**<br>In his seminal book *Principles of Economics*, British economist Alfred Marshall describes industrial districts, which are clusters of small or medium size organizations physically grouped within a fairly limited area, characterised by "extensive local inter-firm linkages" (Harrison, 1992, p. 469). Industrial districts based on inter-firm networking can lead to the creation of industrial symbiosis (Chertow, 2000). |
| **1947** | George Renner | Article: *Geography of industrial localization* | **Industrial Ecology starts to emerge as a concept**<br>Renner evokes the possibility that companies may exchange waste as raw materials but does not coin the term "industrial ecology" itself. He does, however, describe the interrelationships as symbioses that occur in nature (Zhang *et al.*, 2014). |
| **1960s** | | | **First studies of environmental impacts of consumer products**, mainly in a comparative context (Guinee *et al.*, 2010) |
| **1966** | Kenneth Ewart Boulding | Book section: *The Economics of the Coming Spaceship Earth* | **Closed economy or "spaceship" economy**<br>First reference to the state of the economy (closed or open); reference to future generations (pre SD); fairness and human capital; ethics and moral<br>"The closed economy of the future might similarly be called the 'spaceman' economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy." |
| **1969** | MRI (for Coca-Cola) | Unpublished | **One of the first partial LCAs** (unpublished), but not named an LCA. This study by the Midwest Research Institute (MRI) quantifies the resource requirements, emission loadings, and waste flows of different beverage containers.<br>The MRI used the term Resource and Environmental Profile Analysis (REPA) for this kind of study, which had a "cradle to grave" approach. |

| Date | Originator | Document (if applicable) | Key concept(s) |
|---|---|---|---|
| **1970s** | Walter R. Stahel | | **Coining of term "Cradle-to-cradle"**<br>Walter R. Stahel is credited for coining the term "cradle-to-cradle" (Ellen MacArthur Foundation, 2011). |
| **1971** | Victor Papanek | Book: *Design for the real world* | **"Design for the Real World"** is credited as the first book in which industrial design takes the environment into consideration. Victor Papanek is considered as an ecodesign pioneer. |
| **1972** | Meadows *et al.* | Report: *The Limits to Growth* | **The planet has limited resources**<br>For the first time, a research team presents scenarios based on dynamic computer modeling in order to simulate interactions between population, food production, industrial production, pollution, and consumption of non-renewable resources. The 'standard run' (or: business as usual) scenario, which predicted a collapse of the global system mid-way in the 21st century, still holds true when compared with 30 years of historical data (Turner, 2008). |
| | Kalundborg Municipality and Statoil | | **Kalundborg Symbiosis** (Denmark)<br>The world's first implementation of industrial ecology where public and private companies buy and sell waste and by-products form each other (Ellen MacArthur Foundation, 2012b).<br>Production manager Valdemar Christensen uses the Danish equivalent of "industrial symbiosis" to describe the Kalundborg eco-park and is credited for coining the term (Dougherty, 1997 in Zhang *et al.*, 2014). |
| **1976** | Walter R. Stahel and Genevieve Reday | Report: *The Potential for Substituting Manpower for Energy* | **First vision of a closed loop economy**<br>Stahel and Reday envisioned an economy in loops and analyzed such an economy's its impact on job creation, competitiveness, resources and waste (Product Life Institute, 2013). |
| **1977** | Preston Cloud | Article: *Entropy, materials and posterity* | **Earliest known occurrence of the term 'industrial ecosystem' in the English language**<br>(Erkman, 2002) |
| **1982** | Walter R. Stahel | | **Foundation of the Product-Life Institute**<br>Stahel opened his independent and non-profit organization in Geneva in order to study and offer consultancy services on what he considers the 5 pillars of a sustainable economy and society: 'nature conservation', 'limited toxicity, 'resource productivity' , 'social ecology' and 'cultural ecology' (Stahel, 2013c). |

| Date | Originator | Document (if applicable) | Key concept(s) |
|---|---|---|---|
| **1986** | Walter R. Stahel | | **Coining of the term "Performance Economy"** (now better known as Functional Economy) |
| **1987** | WCED | Report: *Our Common Future* | **Sustainable development definition**<br>"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:<br>• the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and<br>• the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."<br>(WCED, 1987) |
| **1989** | Robert Frosch and Nicholas Gallopoulos | Article: *Strategies for Manufacturing* | **This scientific article is perceived as a founding moment for industrial ecology**, even if the field's fundamentals appeared much earlier. The authors suggested the concept of "an industrial ecosystem" which then received widespread attention. |
| | Pearce, Markandya and Barbier | Report: *Blueprint for a Green Economy* | **Coining of "Green economy"** in a report for the UK government by a group of leading environmental economists. But there is no further reference to green economy in the report, apart from its title (Allen and Clouth, 2012). |
| **1990** | David William Pearce and R. Kerry Turner | Book: *Economics of Natural Resources and the Environnement* | **The term "Circular economy" is coined**<br>Pearce and Turner called Chapter 2 of their book "The Circular Economy" and are credited for coining the term. |
| | Thomas Lindhqvist | Report: *From the Cradle to the Grave – six studies of the environmental impact of products* | **Extended Producer Responsibility is introduced in Sweden**<br>Through his report to the Swedish Ministry of the Environment, Lindhqvist introduces the idea of EPR (Lindhqvist, 2000). |
| **1992** | William McDonough and Michael Braungart | Manifesto: *The Hannover Principles. Design for Sustainability* | **Design for Sustainability**<br>McDonough and Braungart prepared these design principles for the city of Hannover, which hosted the Expo 2000 World Fair. Their collaboration on this document spurred on the creation of their firm, MBDC, LLC and of the Cradle-to-cradle book and subsequent projects. |

| Date | Originator | Document (if applicable) | Key concept(s) |
|---|---|---|---|
| | Thomas Lindhqvist | | **Lindhqvist proposes a definition for Extended Producer Responsibility for the first time in the English language**<br>(Lindhqvist, 2000) |
| **1992** | Jelinski *et al.* | Book: *Industrial ecology: concepts and approaches* | **First book on Industrial Ecology** |
| | UNCED | Report: *Agenda 21,* Chapter 4 | **Sustainable Consumption**<br>The United Nations Conference on Environment and Development (UNCED) establishes the concept of sustainable consumption |
| **1994** | UN | | **Oslo Symposium on Sustainable Consumption** |
| | John Elkington | | **Coining of the term "Triple Bottom Line"**<br>(Henriques and Richardson, 2004) |
| **Mid-1990s** | Many authors | | **Scientific articles on Ecodesign start to be published** |
| **1997** | Janine Benyus | Book: *Biomimicry* | **Biomimicry**, a nature-inspired design philosophy, is launched |
| **2000s** | | | **Emergence of "ecological transition"** (and associated terms) in scientific publications but also on the policy level. |
| **2001** | Rotmans, Kemp, van Asselt | Report: *More evolution than revolution: transition management in public policy* | **Transition management**<br>Report that would lead to the adoption of a transition management approach in the Fourth Dutch National Environmental Policy Plan (NMP4), mainly for energy (Rotmans *et al.*, 2001). |
| **2002** | United Nations | Report: *Johannesburg Plan of Implementation (JPOI) of the World Summit on Sustainable Development* | **Sustainable consumption and production**<br>Sustainable consumption and production (SCP) is an overarching objective of and an essential requirement for sustainable development. It is based on framework in which life cycle perspective is central and the goal is to achieve resource efficiency through the decoupling of natural resource use and environmental impacts from economic growth (UNEP, 2015a).<br>Sustainable production and consumption can be defined as production and use of products and services in a manner that is socially beneficial, economically viable and environmentally benign over their whole life cycle (Sustainable Production and Consumption, 2015). |

| Date | Originator | Document (if applicable) | Key concept(s) |
|---|---|---|---|
| | UNEP and SETAC | | **Creation of the Life Cycle Initiative**<br>A partnership between UNEP and SETAC which aims to promote life cycle thinking globally and facilitate the exchange of knowledge of over 2,000 experts worldwide. |
| | McDonough and Braungart | Book: *Cradle-to-cradle: Remaking the Way We Make Things* | **Publication of the book "Cradle-to-cradle: remaking the way we make things"** |
| **2003** | UNEP and UN DESA | | **Creation of the Marrakech Process**<br>The Marrakech Process is an informal and global multistakeholder process launched in response to Chapter III of the Johannesburg Plan of Implementation (JPOI). It has 2 main objectives:<br>1) to promote sustainable consumption and production (SCP) policies, programmes and projects the development and implementation and to provide support for governments, the private sector and other actors in SCP implementation at national and regional scales;<br>2) to facilitate a 10 Year Framework of Programmes (10YFP) on SCP (UNEP, 2015b). |
| **2006** | Rob Hopkins and Naresh Giangrande | | **Founding of Transition Town Totnes (TTT)**, in the city of Totnes which became the first transition town, and whose example would soon be followed by other cities. The Transition Network was set up a few years later to support emerging local Transition Initiatives. |
| | Walter R. Stahel | Book: *The Performance Economy* | **The Performance Economy**<br>Also known as the Functional Economy, the Performance Economy is an economy that seeks to decouple growth from resources consumption and create new business models based on selling performance (or service) rather than goods. |
| **2008** | China adopts a Circular Economy legislation | | **The Circular Economy Promotion Law of the People's Republic of China is adopted** |
| | UNEP | | **Revival of the "green economy" concept**, notably through UNEP's Green Economy Initiative, which aim is to provide analysis and policy support for investment in green sectors and for greening other sectors (Allen and Clouth, 2012). |
| **2009** | UK Government | | **"Low Carbon Transition Plan"** |
| **2010** | Ellen MacArthur | | **Creation of the Ellen MacArthur foundation** |

| Date | Originator | Document (if applicable) | Key concept(s) |
|---|---|---|---|
| | Rachel Botsman | Book: *What's Mine is Yours* | **Coining of the term "Collaborative Consumption"** |
| | William McDonough and Michael Braungart | | **Creation of the "Cradle-to-cradle Products Innovation Institute"**<br>McDonough and Braungart gifted the C2C license to the Products Innovation Institute, which then became the Cradle-to-cradle Products Innovation Institute (Cradle-to-cradle Products innovation Institute, 2014). |
| **2011** | Michael E. Porter and Mark r. Kramer | Article: *Creating Shared Value* | **"What is good for society is good for business";** call for transformation of capitalism<br>**Innovation is based on the business case of unmet social needs**<br>**3 core areas of operationalization:**<br>• Redesigning products and markets<br>• Redefining the value chain<br>• Creating local community development clusters |
| **2012** | French government | | **Launch of the "ecological transition"**, a multi-stakeholders process towards a sustainable economic development. |
| | UN | Plan: *10YFP* | **Launch of the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns (10YFP)** |
| **2013** | ECOFOLIO, KEDGE Business School, FEDEREC, Fondation Nicolas Hulot, GrDF, Le Groupe La Poste and SFIC | | **Foundation of the Circular Economy Institute** (France) |
| **2014** | HEC Montréal, Polytechnique Montréal and Université de Montréal | | **Foundation of EDDEC Institute for Circular Economy** (Québec, Canada) |

# 3 What is, or what should be, Circular Economy?

This chapter aims to create a compendium of major CE conceptual and operational definitions. Building on section 2, it also aims to succinctly delineate the differences between what certain organizations think CE is and what it "should" be, in the sense that CE is not an existing practice that can be described but a proposed vision of a socially constructed economic and industrial system. Section 3.1 presents the major definitions of CE and section 3.2 discusses the major implementation propositions implementing CE. Brief discussions and key takeaways are also presented.

## 3.1 Definitions of Circular Economy

In the last 5 years, many types of organizations have been interested in CE and have written or theorized about its concepts and its potential benefits. Business rhetoric and marketing "buzz" has also been produced about the concept, making it sometimes difficult to discern between the hopes and aspirations that are injected into the concept and the supported facts. This section therefore attempts to concentrate on facts and neutral concepts and does not attempt to introduce a bias or an opinion about them at this stage.

### *3.1.1 The Ellen MacArthur Foundation*

Created in 2010, the Ellen MacArthur Foundation (hereafter named "EMF") is a think tank whose sole mission is to spread the widest possible use of CE. The EMF views CE as:

> *"an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models."* (Ellen MacArthur Foundation, 2013b, p.7)

CE is presented as a resilient, long-term model supposed to enable the decoupling of economic growth and development from the finite resources consumption, as well as providing innovation opportunities in all sectors (Ellen MacArthur Foundation, 2013b). The model is pegged against the "linear" economy which is arguably focused on the 'take, make, dispose' model (basically: cradle to grave versus cradle-to-cradle) while using (too much) resources powered by (often) non-renewable energy. CE therefore replaces disposability with restoration (Nguyen *et al.*, 2014).

A circular economy creates value based on use instead of consumption and creates or maintains value by using the smallest possible industrial loops, distinguishing between "technical" and "biological" inputs and outputs (called nutrients). It also intelligently manages stocks (as opposed to managing throughput) (Ellen MacArthur Foundation, 2013 in Butterworth *et al.*, 2014), which can all be summed up as "materials stewardship". According to the EMF, CE is focused on **eco-effectiveness** rather than on **eco-efficiency** and on a holistic optimization of all components, making it a framework which places great focus on design and on systems thinking.

***Efficiency versus effectiveness, and equity***

The EMF takes care to make a clear distinction between eco-efficiency and eco-effectiveness. According to the EMF (2013b), eco-efficiency is strongly associated with the linear economy in that it basically aims to minimize the "volume, velocity and toxicity" of the "take-make-waste" (or cradle to grave) materials flow but is not able to make the flow fully "circular", notwithstanding recycling efforts (which are considered downcycling). Eco-efficiency is somewhat generally discredited in CE literature.

At the opposite end of core CE values is eco-effectiveness, which favours a transformative approach based on creating cradle-to-cradle 'metabolisms' (vocabulary taken directly from C2C literature) which enable materials to maintain value and create a "positive 'recoupling' of economy and ecology" (Ellen MacArthur Foundation, 2013b, p.23). This dichotomy between eco-effectiveness and eco-efficiency can be traced back directly to C2C's stance on the subject, as has been presented in section 2.6.

The WBCSD fully embraces eco-efficiency as "the business end of sustainable development" (WBCSD, 2000, p. 1). The WBCSD (2000) considers eco-efficiency as a management philosophy which enables companies to be more environmentally responsible while still being profitable, by encouraging companies to create more value from lower resources consumption and reduced emissions through 3 key objectives: 1) resources consumption reduction, 2) environmental impacts reduction and 3) product service value increase.

It should however be noted that effectiveness and efficiency (without their environmental prefix) have meanings in other scientific fields that may contribute to reframe the term's comprehension in the context of deciphering CE.

Taken from a different but related field (economic policy in support to climate change adaptation), economic effectiveness means that an instrument is able to appropriately address multi-level barriers to adaptation. Economic efficiency means that an instrument is able to appropriately achieve the most social benefits for the lowest cost. A third performance criteria is also integrated in the framework: **equity**, which in the adaptation context relates to the various effects ('distributional impacts') of instruments' impacts on different populations, with special care to avoid social perverse effects or conflicting incentives (Cimato and Mullan, 2010). Equity relates to the often forgotten second part of Sustainable Development's Brundtland definition, namely "the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given" (WCED, 1987).

UNEP is explicit on the fact that it will be impossible to achieve economic and social goals in developing countries without achieving the environmental Sustainable Consumption and Production (SCP) objectives as well as ensuring environmental sustainability (Millennium Development Goal 7). Rural and poor people living in developing countries are the principle beneficiaries of economic development as well as the most liable to negative environmental and climatic variations (Ekins and Lemaire, 2012).

Equity in CE should thus dictate that because they are the most potentially affected by the linear economy, poor and rural populations in developing countries should be the prime beneficiaries of a more circular economy. However, these questions that can be said to lie at the heart of the social dimension of SD, are almost completely absent from CE literature. This ascertainment is problematic, at best.

The EMF postulates that focusing solely on efficiency will fail to foster longer-term solutions. They posit that "a change of the entire operating system seems necessary" (Ellen MacArthur Foundation, 2013b, p.22).

CE acts as a framework within which producers retain the ownership of their goods, providing only functions to their clientele, who shift their status from buyers of products to buyers of a service, which is core to Functional Economy. This way of producing and living implies that new systems (such as take-back or extended insurance coverage) need to emerge, congruent with new business models, which should all converge on the general idea of durable products and dematerialization (turning products into services). Figure 3-1 visually presents the EMF's conceptualization of CE. The EMF's is one of the most widely accepted conceptual definitions at the moment and has garnered a wide adoption.

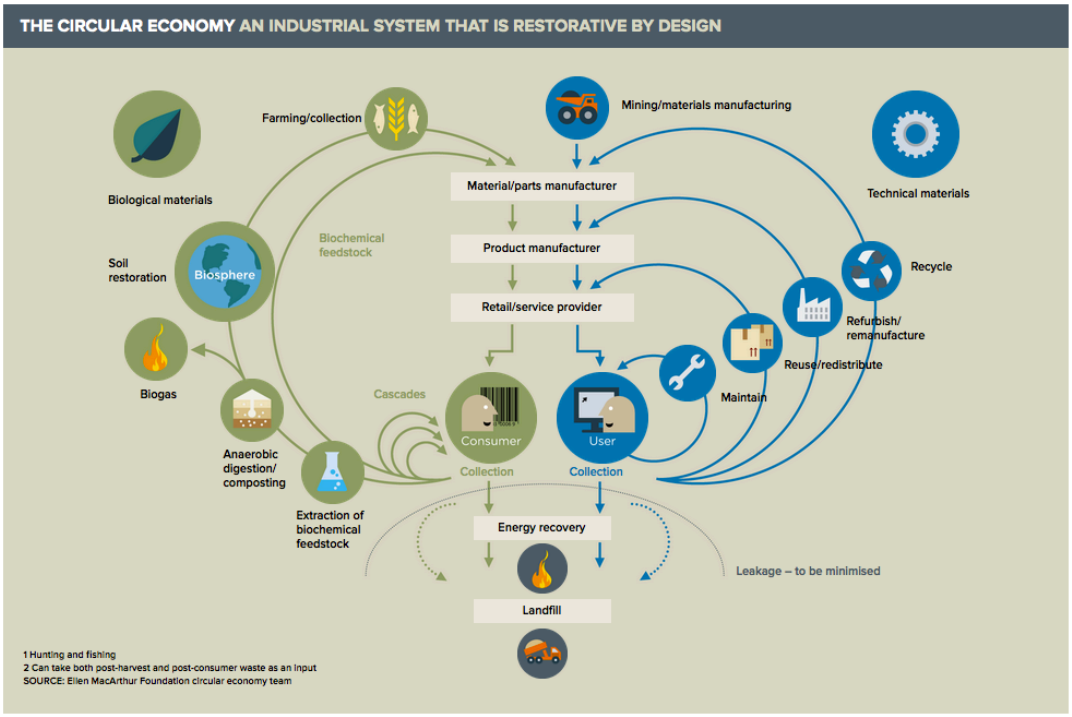



**Figure 3-1: The Circular Economy diagram.**

From: Ellen MacArthur Foundation (2012a)

### *3.1.2 Other definitions*

Many organizations have taken the EMF's definition and mobilized it, whole, truncated or modified, in their communications and official documentation, such as the Institut de l'économie circulaire, who view CE as inspired by natural ecosystems with the ultimate goal of achieving economic growth decoupled from resources depletion (Institut de l'économie circulaire, 2013). The Netherlands within its "Green Deal", has adopted a CE framework which takes the EMF's main conceptual elements within its own definition (Government of the Netherlands, 2014).

Although there is arguably no stabilized definition according to the French *Agence de l'environnement et de la maîtrise de l'énergie* (ADEME), CE can nevertheless be defined as "an exchange and production based economic system that, at all stages of the product or service life cycle, aims to increase the efficiency of resource use and reduce the impact on the environment while developing the well being of individuals" (Geldron, 2013).

CE's general aim is to drastically reduce waste of resources, including but not limited to raw materials and energy, in order to decouple resources consumption from GDP growth while ensuring environmental impacts reduction and increase human well-being, including maintaining or increasing employment. In short, "it is to do more and better with less and appears to be an operationalization framework of sustainable development in a context of economic crisis" (Geldron, 2013, p. 3; translation by the ILC Chair). This view is also mobilized by Juillard (2013 in Fernandez *et al.*, 2014), who notes that SD is a primer to an energy transition and CE can be its catalyst (Fernandez *et a*l., 2014), creating a bridge across SD, Ecological Transition and CE.

This transitional, or bridge, aspect of CE is supported by independent, public organization TNO, which posits that CE is a transition economy towards renewable and sustainable energy supplies, which aims to manage more consciously energy and raw materials, notwithstanding evolutionary designs or systems. It makes the case for the fact that some regions (namely: the Netherlands) already possess some components of CE systems, such as second-hand marketplaces, industrial symbiosis parks and repair/refurbishment markets (Bastein *et al.*, 2014).

ADEME identifies 3 conceptual and research fields:

- **Production of goods and services:** whether talking about sustainable supply chain management and ecodesign, industrial ecology and operationalization of the functional (or performance) economy
- **Consumption:** in terms of demand and behaviour, this field articulates itself around responsible purchasing, the appropriate use of goods and the trend towards reuse and repair
- **Waste management:** while responsible production and consumption limit waste production, management of the residual waste must take into consideration recycling and, if appropriate, energy recovery (Geldron, 2013)

Figure 3-2 presents the way ADEME conceives of CE.

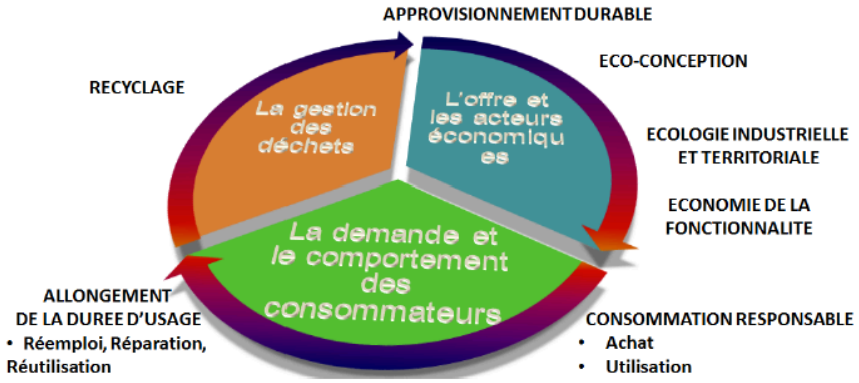



**Figure 3-2: Circular Economy diagram.**

From: Geldron (2013), p. 4

In this conceptualization, the systemic, restorative/regenerative/resilient, design and multiple loops aspects are muted, (if not altogether put aside) to the benefit of mostly materials stewardship aspects.

The *Environnement, développement durable et économie circulaire* (EDDEC) Institute in Montreal follows the ADEME definition but adds to it the aspiration that CE can be a coherent framework which can

federate once isolated, but previously proven efforts, initiatives and strategies. It also has a strong aim to unify and mobilize actors through new technologies and business models (EDDEC, 2014). EDDEC highlights the use of new or proven strategies such as ecodesign (upstream), industrial ecology (production), functional economy (production) and collaborative consumption (use) as part of CE's toolbox (EDDEC, 2014). This view is supported by the Implementation Centre for Circular Economy (ICCE) who adds to the list C2C principles (ICCE, 2015) and also supported by Accenture (2014). Figure 3-3 presents EDDEC's vision of CE.


**Figure 3-3: Circular Economy diagram.**

From: EDDEC (2014)

The European Environment Agency (EEA) adds to the concept the fact that CE fosters a production and consumption system that "generates as little loss as possible" (EEA, 2014, p.12). Its visual diagram is presented at Figure 3-4.


**Figure 3-4: How can we make our economy circular and resource efficient?**

From: EEA (2014), p. 13

The *Institut de préparation à l'administration et à la gestion* (IPAG) Business School introduces the fact that a social approach is encompassing within the framework of general economic and environmental preservation reconciliation (Fernandez *et al.*, 2014). IPAG defines CE as an innovative management style that integrates social, economic and environmental dimensions in a business approach that stimulates local economic development and job creation while reducing the impact of human activity on the environment and resources through cooperation of local actors. It should be noted that IPAG is one of the only organizations who positions the social dimension as being part of the CE concept, while paradoxically mentioning that the social sphere does not seem to fit explicitly in existing CE literature. The authors developed a body of hypotheses claiming that the social sphere has no place in the CE concept, but that it could be introduced as a result of long-term CE effects; whereas CSR is a useful approach for integration of social goals in CE, which requires adaptation, recognition and empirical support tailored to the CE concept (Fernandez *et al.*, 2014).

Accenture (2014) focuses on CE's definition as it pertains to companies' competitiveness. According to Accenture, companies must find revenue generation ideas within products' use and disposal cycles within the value chain to attain the required CE business models. They highlight the fact that every aspect of a company must become 'circular', bringing about a crucial re-alignment of both customer and business incentives, leveraged from disruptive technologies and putting design at the forefront of the innovation process. They postulate that CE is an evolution of business that enables companies to gain a major competitive edge. Accenture calls this the 'circular advantage'.

So far, it seems clear that CE definitions range from encompassing large concepts to pinpointing specific strategies. The EMF puts forward the most comprehensive and complex definition, by positioning it as a new industrial system that is (amongst other things) restorative and regenerative, while advocating new business models that are mostly inspired by Functional Economy and Industrial Ecology. ADEME's definition introduces the social dimension in terms of human well-being, while adopting a view akin to

Sustainable Production and Consumption (SPC) and the Green Economy put forward by the UN, in which the decoupling between economic growth and environmental impacts is key.

As well, it seems that the definitions of efficiency and effectiveness that the EMF champions (and which are derived directly from C2C literature) have not quite percolated to other organizations who promote definitions of CE, who focus more on efficiency and value creation. As has been presented at section 3.1.1, the WBCSD views efficiency as business' way of supporting SD, while disciplines such as economics, through policies in support of climatic adaptation, view effectiveness as a way to appropriately address barriers to adaptation (Cimato and Mullan, 2010). Effectiveness, restoration and systems thinking which are core in the EMF's definition of CE are sidebars in other definitions, if not altogether absent. However, if CE in its most comprehensive expression is to be deployed, these concepts seem rather crucial. The difference between a *regenerative and restorative system*, and one that is based on *material stewardship* traces two different paths that may be either competitive or collaborative. Roughly, there seems to be two types of definitions: one which advocates a disruptive way for various stakeholders to be working together towards a planetary goal, and the other – more widespread – which traces a path towards a transition that precludes disruption and allows for 'business as usual', infused with innovation.

In its most comprehensive and disruptive expression (as championed by the EMF), CE needs to be implemented at all levels and would thus introduce unprecedented, rather rapid and deep change that would make collaboration necessary. If governments and regions decide to move forward with ambitious CE legislation, private actors would need not only to adapt in a fairly short time, but they would also need to learn to cooperate within an interlocking system made up of various metabolisms powered only by renewable energy that would successfully ensure our collective survival. If CE is to be implemented in a more modest way, as a transition towards a more sustainable (or circular) kind of economy or industrial system, ADEME's definition is probably more in line with what could be a reality (at least in Europe) within the next 5 to 15 years. Thus, it may just be that the EMF's definition, while supported by tools and some business cases, is more of a projected vision of the future in 20 or 30 years, while definitions that are more grounded in operationalization have less of the holistic aspects and are more guided by concrete strategies and down to earth considerations. It may also be that at present, CE is best exemplified in isolated and controlled cases (ranging from business cases to regional implementation), but faces serious challenges when pegged against an integrated global or at least national deployment.

Last but not least, it can be questioned whether CE is indeed, as its name indicates, a revolutionary global *economic* program (i.e.: radically changing how resources are generally allocated within the global community) or a new *industrial* system, focused on deeply changing the way business is conducted, techniques are developed and materials flow. This blurry episteme is probably one of the many reasons why CE's definition is still unclear and variegated at the moment.

CE may well embed various components, economic as well as strategic, environmental and perhaps even social, but these need to be better defined. CE will become clearer to all stakeholders when its main strengths (as well as its blind spots) will be made more obvious, as it is difficult to imagine that CE can be everything to everyone.

The next sub-section focuses on CE's main principles

### *3.1.3 Circular Economy Principles*

According to the Ellen MacArthur Foundation (2013a), CE has 5 pillars:

- Systems thinking

- Waste is food
- Diversity is strength
- Design out waste
- Renewable energy

According to IMSA (2013), 'systems thinking' is the most fundamental of the CE pillars. They define it as "the ability to understand how parts influence one another within a whole, and the relationship of the whole to the parts" (IMSA, 2013, p. 16)

As the EMF describes two types of nutrients (technical and biotic), there are two different ways of conceiving the cycles for each type of nutrient, because of their inherent differences but also in order to keep, gain or create as much value as possible.

For the technical nutrients, the feedback loops include:

- **Products maintenance and repair:** the goal is to keep them in circulation as long as possible with as high a value as possible)
- **Goods reuse and redistribution**: this loop's goal is to avoid value loss and optimize contribution to CE. It includes the existence, maintenance and optimization of an organized second-hand market
- **Goods refurbishing and remanufacturing:** the goal of this loop is to repair and/or replace failed parts and/or components, which results in a product with a shorter life span than the equivalent when new. It involves quality control and consumer guarantees.
- **Recycling**: this circular process aims to recover elements that can serve as input for production processes. It results in loss of original product's added value.

For biotic nutrients that cannot be kept in circulation the same way as technical nutrients, the general goal is to gain as much value as possible from them through cascades, before eventually returning them to the soil as nutrients. These cascade of processes include:

- **Extraction of biochemical feedstock:** this involves high-quality raw materials extraction from biomass (e.g.: bio refining) in order to yield often small volumes of materials, power, fuel and high-quality chemicals
- **Renewable energy supply through biogases:** anaerobic digestion of organic material by micro-organisms and the absence of oxygen creates biogases such as methane
- **Use as non-toxic amendments in agriculture:** all biotic nutrients should be used as non-toxic fertilizers and other agricultural amendment

### *Creating value in CE*

According to the EMF (2014), specific circular processes have various economic yields according to different combinations of products, components and materials. However, the EMF points out four basic principles of value creation in CE:

- **'The power of the inner circle':** a shorter/tighter loop usually results in more savings and potential benefits because inherent costs such as labour and energy are less. Thus, more value is retained in the final product because the savings and possible benefits are more abundant than goods produced in longer loops. As an example, a product retains more value after repair and maintenance than by recycling some of its components.
- **'The power of circling longer':** value is created by the frequency a product (re)enters a cycle and the length for which it is used.
- **'The power of cascaded use and inbound material/product substitution':** a cascade loop is created when a product of more often a component is used across different product categories,

as for example cotton that may be used in a first loop for clothing, then for furniture filling, and ultimately for insulating. Value is created by the difference between the cost (included the embedded costs) of a virgin material, and the marginal costs of the material that is brought back into a loop for repurposing.

- **'The power of pure cycles:** this value creation principle is mobilized if the end of life of a product has been considered at the design phase by ensuring, for example, that the product is easy to take apart and/or is made of non-toxic materials.

The 4 types of cycles promoted by the EMF are presented visually at Figure 3-5.

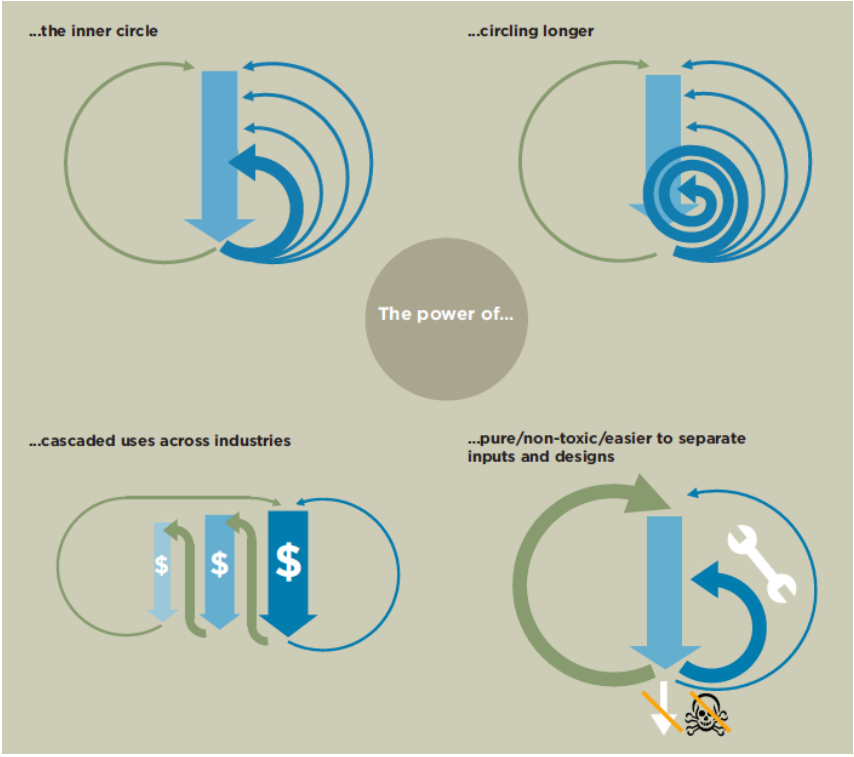



**Figure 3-5: Sources of value creation for the Circular Economy.**

From: Ellen MacArthur Foundation (2014), p. 16

According to Accenture (2014), there are 4 value creation areas in CE: 1) lasting resources, 2) liquid markets, 3) linked value chains and 4) longer life cycles. The 4 value creation areas are presented at Figure 3-6. These 4 areas are essentially the same as what the EMF posits.

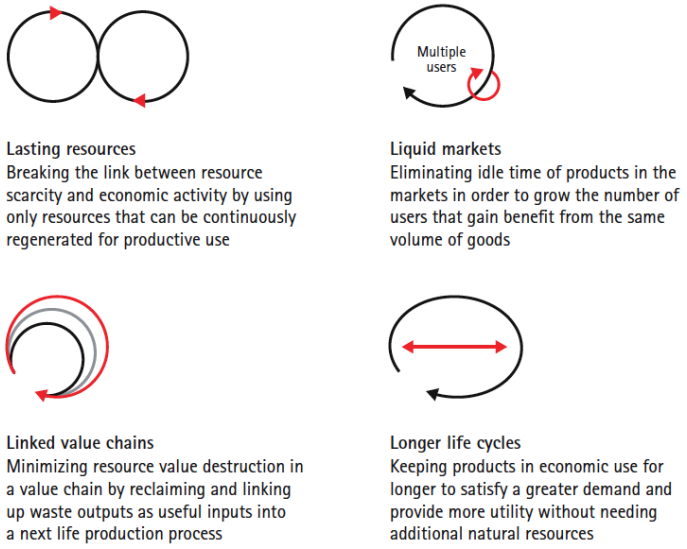



**Figure 3-6: Areas of value creation in the circular economy.**

From: Accenture (2014), p. 6

### *3.1.4 Discussion and key takeaways*

In terms of definition and meaning, CE cherry-picks through many approaches, concepts and frameworks, many of which have been outlined in chapter 2. It takes C2C's basic DNA and adds to it principles from Functional Economy, solidifying and credibilizing it with Industrial Ecology precepts. What is left aside are the historical links and many ties to SD, namely SCP and the Marrakech Process goals, but also more problematic elements such as the third dimension of SD (social). It is either a sign of a knowledge field that is eager to please the business world and lacks an epistemic foundation, or the symptom of a young field that after an incubation period, opens itself to the outside world and tries, in the process, to take in adjacent fields (Audet, 2015).

As well, CE claims to be based on effectiveness ("doing the right thing") but many definitions from various organizations seem to focus on efficiency ("doing things right"), while some concepts such as Functional Economy aim to reconcile both ("doing the right thing the right way"). Equity and the social dimension of SD are absent (or have a very weak presence) in CE literature.

From the overview of CE's core principles, it can be understood that materials flow and stewardship is the common denominator across all value chains and that business must adapt itself to circularity by changing its models in order to gain the most value from the various loops. There are five important technical (and value creating) loops in CE, where the tightest loop (the 'inner circle') yields the highest value and the looser one yields the least value:

1. Product maintenance
2. Product reuse/redistribution
3. Product refurbishment/remanufacture
4. Product recycling
5. Reprocessing of technical nutrients

## 3.2 Implementing Circular Economy

### *3.2.1 Implementation at region or country scale*

According to IMSA (2013), cooperation between government, civil society and private actors is essential for successful implementation of CE, suggesting that it cannot be implemented by companies alone and must be operationalized at a larger scale, whether regional or national. The most elaborate roadmap towards a national implementation of CE was produced by IMSA for the Dutch Circle Economy[5].

According to IMSA, there are 'niche' steps and mainstream steps to put into motion, in order to attain CE. First, a certain number of bottom-up initiatives (niche steps) must be in motion, within a linear framework but with a goal to transition towards CE. Second, top-down steps need to occur in order to transform business in the longer term (IMSA, 2013). Table 3-1 offers an overview of niche steps and obstacles to CE at a regional or country scale.

[5] Circle Economy is a Dutch cooperative based in Amsterdam whose mission is to facilitate and accelerate the transition towards a circular economy. It collaborates with over 50 national and international partners and members on various conceptual and applied projects. http://www.circle-economy.com

## Table 3-1: Overview of obstacles, niche steps and mainstreaming steps for a circular economy

| Obstacles | Niche steps | Mainstreaming steps |
|---|---|---|
| **1. Major up-front investment costs** | 1. Set up a simple index for circular performance. Organisations (companies, harbours, governments, investors) can use this to give incentives to their value chain partners encouraging circularity | 10. Replace traditional financial reporting by mandatory and accountable integrated reporting and develop the concept of True Value |
| **2. Environmental costs (externalities) are not taken into account** | | |
| **3. Shareholders with short-term agenda dominate corporate governance** | | |
| **4. Recycled materials are often still more expensive than virgin** | | 11. Create a tax shift from labour towards natural resources |
| **5. Higher costs for management and planning** | 2. Encourage experimentation, innovation and redesign. In NL, use Green Deals to remove legislative obstacles and support access to finance and a resource passport | |
| **6. Unlevel playing field created by current institutions** | | 12. Implement a new economic indicator beyond GDP that steers towards circularity |
| **7. Financial governmental incentives support the linear economy** | | |
| **8. Circularity is not effectively integrated in innovation policies** | | |
| **9. Competition legislation inhibits collaboration between companies** | 3. Gather and spread successful business examples | 13. Establish international independent systems to organise materials flows, including data gathering and exchange, labelling and certification, impact assessment, standardisation and material pooling |
| **10. Recycling policies are ineffective to obtain high quality recycling** | 4. Integrate circular economy principles in education and training programmes (leadership, in-company, MBA, economics, engineering, design and policy sciences) | |
| **11. Governance issues concerning responsibilities, liabilities and ownership** | | |
| **12. Limited application of new business models** | 5. Develop a long-term company vision | |

<table>
<tr><td>13. Lack of an information exchange system</td><td rowspan="2">identifying linear risks and circular economy opportunities</td><td rowspan="4"></td></tr>
<tr><td>14. Confidentiality and trust issues hamper exchange of information</td></tr>
<tr><td>15. Exchange of materials is limited by capacity of reverse logistics</td><td>6. Search for material pooling opportunities</td></tr>
<tr><td>16. Lack of awareness and sense of urgency, also in businesses</td><td rowspan="3">7. Promote circular products using modern marketing techniques and social media</td></tr>
<tr><td>17. GDP does not show the real progress or decline of our society</td><td rowspan="3">14. Adjust national and international government policies for corporate governance, accounting, competition, recycling, and health, safety and environment</td></tr>
<tr><td>18. Resistance from powerful stakeholders with large interests in status quo</td><td rowspan="2">8. Prepare roadmaps for established economic sectors</td></tr>
<tr><td>19. Limited attention for end-of-life phase in current product designs</td><td>9. Initiate and stimulate stakeholder fora about the circular economy Set up a simple index for circular performance.</td></tr>
</table>

### 3.2.2 Circular Economy in various legislations

Since the 1990s, several countries have implemented more or less complex versions of CE, starting with Germany through the "Avoidance, Reduction, Disposal", which eventually culminated with the Circular Economy and Waste Law (Government of the Netherlands, 2014). In the early 2000s, Japan passed excess waste and resources scarcity policies as well as a Law for the Promotion of Efficient Utilization of Resources (Ellen MacArthur Foundation, 2014). China adopted its Circular Economy Promotion Law in a cleaner production focus, which will be developed at section 3.2.3 with the aim to develop cleaner production methods at multiple levels.

In Europe, the premise of a CE policy could be discerned as of 2011 in the flagship initiative for a resource-efficient Europe, which was established within the Sustainable and intelligent growth strategy for Europe 2020 (Lassaux, 2015). In 2012, European Resource Efficiency Platform (EREP) manifesto enabled an agreement amongst EU member states, concerning resource efficiency and CE, with an emphasis on job creation and global competitiveness (Butterworth *et al.*, 2014). In 2013, the organization Circle Economy and the Dutch government signed a 'Green Deal' commitment to create a national CE program (Butterworth *et al.*, 2014). The European Union, during the Davos forum of 2013, created a CE discussion platform, which eventually led to the establishment of a non-binding resource productivity target for E.U. member states, the 'GDP relative to Raw Material Consumption'. Other notable E.U. measures include the resource stress tests aimed at companies, green public procurement and CE funding initiatives. Other E.U. policies, while not explicitly about CE, nonetheless help with the deployment of some of its core tenets, such as the EU waste framework directive and the ecodesign directive (Raksit, 2014).

In 2014, the MISTRA foundation Stockholm launched a CE design call for proposals based on resource efficiency. The Scottish government announced the creation of a Remanufacture expertise center, for which the European program Horizon 2020 was awarded €1.5m. As well, in the last 2 years, China, South Korea and the U.S. have been investing in their respective remanufacturing industries (Stahel, 2015). In Ireland, a national CE goal has been established (Circle Economy and PGGM, 2014). CE is also increasingly being mobilized in Switzerland (regulatory framework for the Green Economy in 2012) and in the U.K. with the Waste and Resources Action Program (WRAP). Various cities have also embraced CE, namely Amsterdam, Rotterdam, Haarlmemermeer (Netherland), Guiyan (China), Phoenix (U.S.), Kalundborg (Denmark) and Masdar City (United Arab Emirates) (Government of the Netherlands, 2014).

A European package on CE was proposed in July 2014 and contained a broad list of legally binding targets, including recycling rates, landfilling, recoverable waste, waste reduction, etc. (Tost, 2015). More specifically, the package consisted of four Communications on sustainable buildings, green jobs and SMEs and a general Communication called "Towards a Circular Economy: Zero Waste Program for Europe" (Lassaux, 2015). The European Commission working group abandoned this first CE package in January 2015; the Commission has however undertaken to prepare a new CE initiative expected to be delivered in Fall 2015. This new package will foreseeably include new legislation, take into account the realities of various EU members and go beyond waste management in order to include a broader view including ecodesign and markets for reused goods and recycled materials (European Parliament, 2015).

### 3.2.3 Circular Economy in China

Faced with serious resources challenges, China's government viewed CE as an alternative development model. The first stage started in 1998 when the concept was introduced and theoretical studies were conducted. From 2001 to 2005, clean production and industrial ecology parks started to be

implemented (Butterworth *et al.*, 2014). In 2002, the government implemented the Circular Economy initiative Development Strategy (Government of the Netherlands, 2014). And in 2008, the Law for the Promotion of Circular Economy in 2008 was introduced (Naustdalslid, 2014).

### *Theoretical development of the Chinese CE*

Generally, China's brand of CE can be traced back to classical ecology and economics authors such as Rachel Carson's 'Silent Spring' (1962) as well as to concepts such as Boulding's and Ward's 'spaceship earth' metaphor (Boulding, 1966; Ward, 1966). In the 1970s and 1980s, the seminal Club of Rome's "Limits to Growth" (Meadows *et al.*, 1972) can also be found within CE's initial foundations, together with the Brundtland Report (WCED, 1987).

The knowledge that has been excluded from the theoretical and ideological foundations of China's conception of CE are scarce resources models and conventional market economics, claiming that the neoliberal market fails to produce a tool that is able to point towards the critical aspect of limited and exhaustible resources, based on existing production and consumption patterns that do not necessarily take absolute planetary limits into consideration. This aspect is positioned directly opposite CE's potential to conduct economic activities within limits but mostly, in an adaptive fashion, by design, according to ultimate planetary balance and according to natural laws. In short, economy and nature are part of the same larger system (Naustdalslid, 2014).

### *Implementation of CE*

The move towards a circular economy (CE) in China was spurred in the late 1990s by the realization that important and fast economic growth and industrial expansion lead the country to rising social inequalities and environmental degradation. China's officials realized that if this situation were left to continue unabated, it would eventually hamper or even stop growth. This resulted in the development of the policy framework of the 'harmonious society'[6], formulated by the 16t$^{h}$ Chinese Communist Party Congress in 2002, aimed at bringing together nature and society in a harmonious relationship, CE being the environmental dimension of the 'harmonious society'. The promulgation of the Law for the Promotion of the Circular Economy in 2008 embodied this change, as it made CE an official overarching economic development goal for China (Naustdalslid, 2014).

This had already been indicated when the primary responsibility of its implementation was transferred from the State Environmental Protection Agency (SEPA) to the National Development and Reform Commission (NDRC) in 2004, thus taking CE from the realm of environmental policy, as is the case in other countries such as Germany, Denmark, Sweden and Japan, into the realm of development and economic policy as it aims at being a way of linking economy and ecology so as to achieve a win-win situation: economic growth and development should be systematically 'decoupled' from environmental degradation (Zhu, 2008; The World Bank 2009; Mathews & Tan, 2011 in Naustdalslid, 2014). Article 2 of the CE Promotion law defines CE as "a generic term for the reducing, reusing and recycling activities conducted in the process of production, circulation and consumption", making the 3Rs principle the

[6] The 18$^{th}$ Party Congress in 2012 further strengthened the official resolve to develop China as an 'ecological civilization' characterized by harmony between man and nature under the epitome 'Beautiful China'. The development of the 'harmonious society' concept was based on a combination of ideological and moral basis whose aim was to achieve a balanced (or sustainable) development for China. It was based on a fusion of traditional Confucianism and Taoism which, combined, would achieve a liberal market guided by the social ideal general harmony and well-being within a stable and orderly design (Yuan *et al*. 2006; Mahoney 2008; Zhongwen 2008; Guo and Guo 2008; Wan 2013 in Naustdalslid, 2014).

central pillar of CE. However, CE is not just concerned with waste management but is a system linking all scarce resources (including water and land) and the economy, moving away from the narrow microeconomic concept of industrial ecology to a more macroeconomic distinction between the neo-classical 'linear economy' and the 'circular interdependence between nature and the economy' of ecological economics (Lu *et al*., 2005 and Shu & Wu, 2007 in Naustdalslid, 2014).

CE is being implemented in China at three levels:

- **Enterprises** (micro) level with the development of cleaner production initiatives
- **Inter-enterprise** (meso) level with the development of eco-industrial parks[7]
- **Societal** (macro) level, with the development of eco-cities and eco-regions, attending to both production and consumption

The campaign for a more balanced development between nature and society was accompanied by the launch of the new 'scientific concept of development', the idea that policies can be implemented as a top-down process based on scientific knowledge. Thus the practical implementation of CE is seen as a gradual transition process directed, controlled and monitored from above, whereas in the more developed industrialized countries, CE is mainly promoted from below by NGOs and civil society, directing their messages at industries and businesses and putting pressure on governments to enact laws and regulations. This macroeconomic approach to CE is mainly founded on the belief that once factual knowledge is acquired on the actual state of society, the appropriate response will follow, which proves its limits in the case of as comprehensive a change as what the 'harmonious society' demands. Indeed, the set of indicators proposed to measure CE programs and national progress lacks social and welfare-oriented indicators and only covers the meso and macro levels of implementation. Also, even if the general legislation to promote CE has been put in place, little progress has been made in the harmonization with other laws (Naustdalslid, 2014).

### *3.2.4 Implementing Circular Economy at company scale: new business models*

After grasping the main principles of CE, individual or groups of companies must be able to implement CE in their day-to-day activities and business models. Various elements useful for achieving this goal exist but are still fairly general. This section aims to provide some insights into this question.

According to the Dutch government, there exist 4 CE elements that can be integrated into business practices. They are:

1. Circular and innovative design
2. New and service-oriented business models
3. Improving competencies along reverse cycles and cascades, including product collection and re-use
4. Enhancing cross-cycle and cross-sector performance (Aldersgate, 2012 and Ellen MacArthur Foundation, 2013 in Government of the Netherlands, 2014).

According to OPAI & MVO Nederlands, 9 principles must be applied for companies to transition towards CE:

1. Potential seeking
2. CE opportunities discernment
3. Financial strategy, external feedback and competencies adjustment

[7] Chinese parks differ from those found in other countries, as they integrate production and residential areas.

4. Use of clear KPIs
5. Avoidance of technical details focus
6. Building of space and feedback for CE strategy development
7. Account for internal resistance
8. Establish budget and plan capacity
9. Make space for learning from mistakes (OPAI & MVO Nederland, 2014, in Government of the Netherlands, 2014).

Parallel to these activities, it is also necessary for companies to evaluate how their core business may be linked to the CE value proposition. In order to do this, a sustainable business modelling can be mobilized, using 3 types of value: 1) value captured, 2) missed/destroyed or wasted value, and 3) opportunity value. Stakeholders must also be taken into consideration, namely: the environment, society, customers, and network actors (Bocken, 2014 in Government of the Netherlands, 2014).

Based on previous studies, Accenture (2014) has identified 5 circular business models. They are:

1. The '**Circular Supplies'** model is infused with C2C philosophy and based on a loop of renewable, recyclable and/or biodegradable resource.
2. The '**Resource Recovery'** model fits with basic Industrial Ecology. It promotes value creation through linked product and industrial life cycles as a way to transform waste into inputs.
3. The '**Product life extension'** model corresponds to one of the core conditions of Functional Economy. It is based on value retention through maintained and/or improved stocks through repair, upgrade, remanufacture and remarketing of products.
4. The '**Sharing platforms'** model is akin to Collaborative Consumption or the Share Economy movement. It has a technological foundation based on enabling users to connect, in order for products or services to be efficiently shared, distributed and their value maximized through a high utilization rate.
5. The '**Product as a Service'** model is the basis of Functional Economy. It serves as an alternative to ownership and transforms consumers into users. It is a downstream model to the 'Product life extension' model and gains customers through a lease or pay-for-use economic arrangement. It is also synergistic with the 'Sharing platforms' model, which may enable it.

The 5 business models are presented at Figure 3-7.

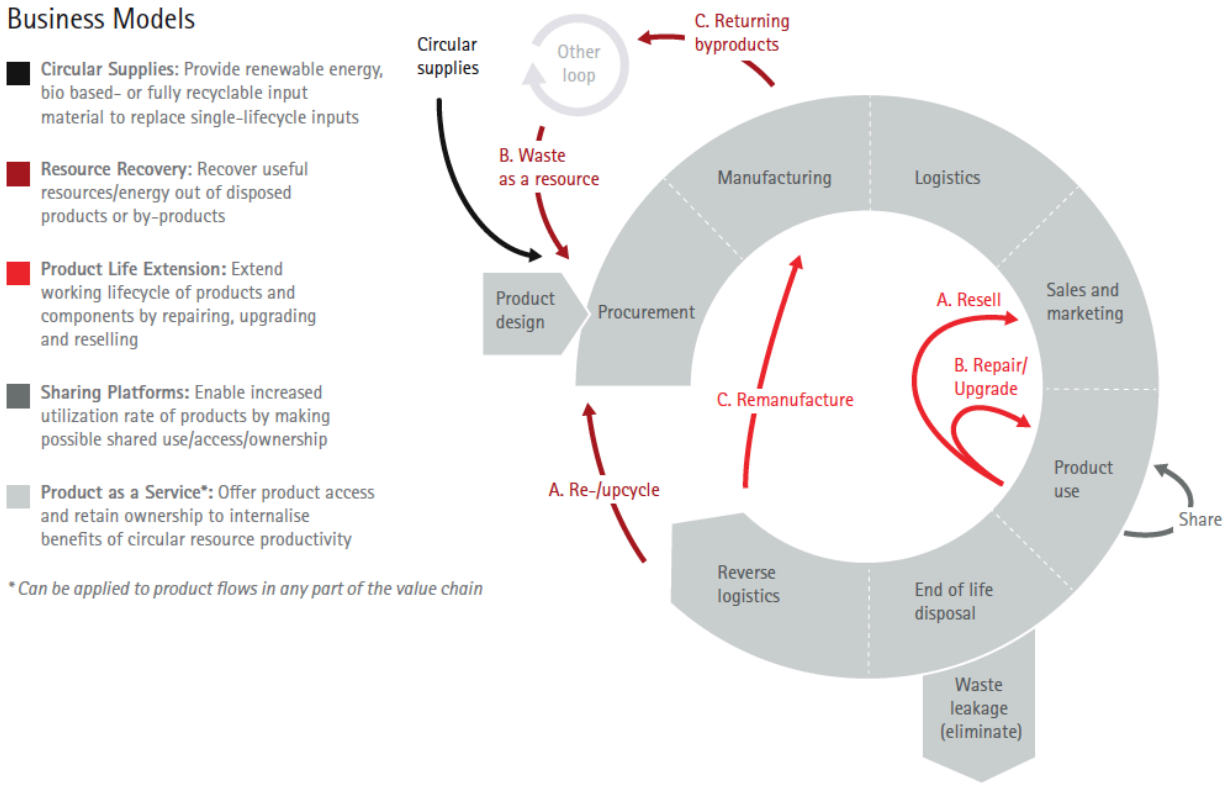



**Figure 3-7: The 5 circular business models.**

From: Accenture (2014), p. 12

The aforementioned business models are supported by 10 disruptive technologies, which are classified within 3 categories:

1. **Digital:** information technologies (IT) enable real-time exchanges between nodes (whether humans, machines or systems) and permits the creation and maintenance of relationships that can be short or long term.
2. **Engineering** (physical technology): engineering makes (re)manufacturing of goods from regenerated resources possible, a crucial asset for the 'Circular supplies' and 'Resource recovery' models.
3. **Hybrid:** a fusion of the first 2 categories, hybrid technologies (part digital, part engineering) allows companies to digitally locate and follow material flows and also support ways to collect, treat and reprocess them.

The 10 disruptive technologies are presented at Figure 3-8.

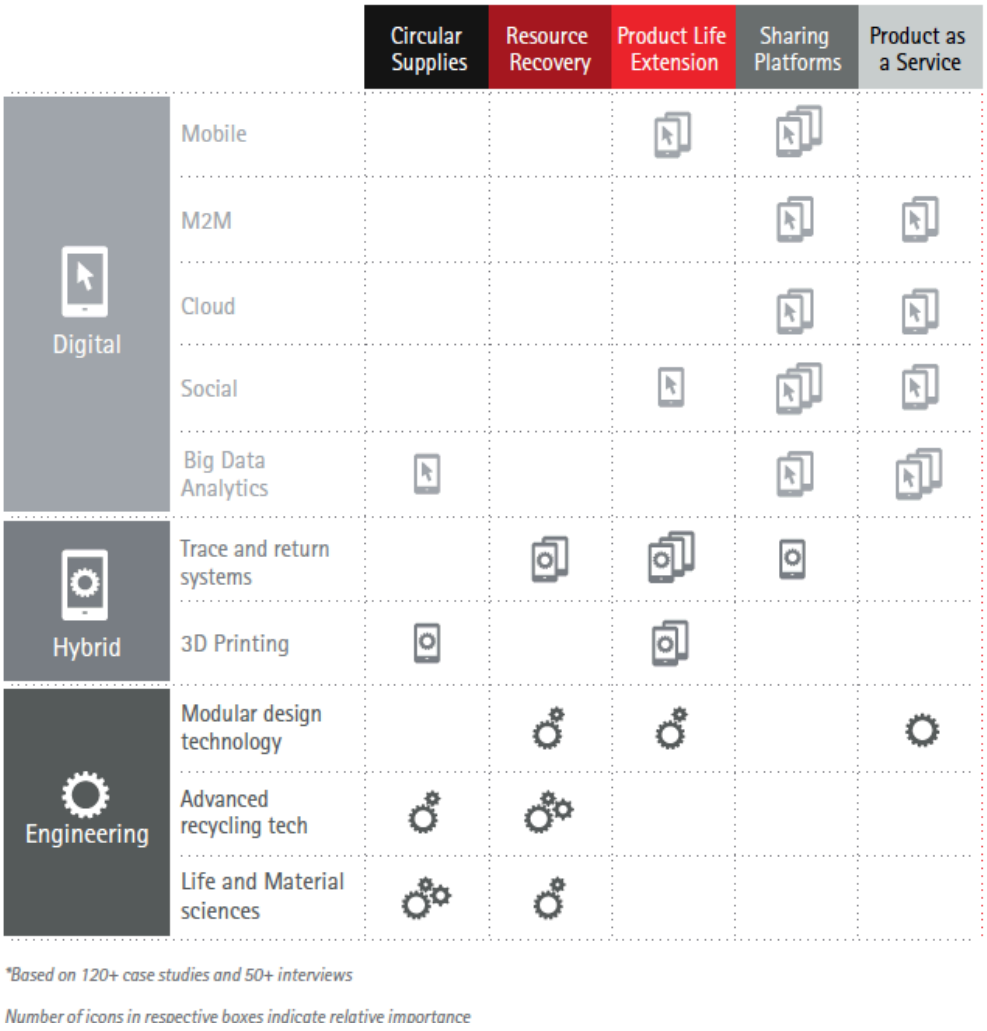



**Figure 3-8: Circular Economy's 10 disruptive technologies.**

From: Accenture (2014), p. 16

### *3.2.5 Barriers to Circular Economy implementation*

Aside form the barriers listed at section 3.2.1, Nguyen *et al.* (2014) from the firm McKinsey list the following constraints for companies considering CE implementation:

1. **'Geographic dispersion':** the size, complexity and global dispersion of supply networks are a major factor in tackling CE initiatives. As well, in order for reverse logistics, take-back or other initiatives to work globally, various legislations need to be synched, which is not the case at the moment. The picture of where, e.g., refurbishment should occur and how to put value on a component post-product dismantling are complex questions that will inevitably result in trade-offs.
2. **'Complex materials':** complex formulations, multiple materials paired with the lack of labelling make post-consumer material identification difficult, at best. These roadblocks are made even more difficult by a lack of tracking and material specifications that are often more complex than need be. As well, the inability (or difficulty) of separating and recuperating valuable materials from the recovery process makes, e.g., valuable raw material extraction difficult and loses value when compared with the cost of the original material.

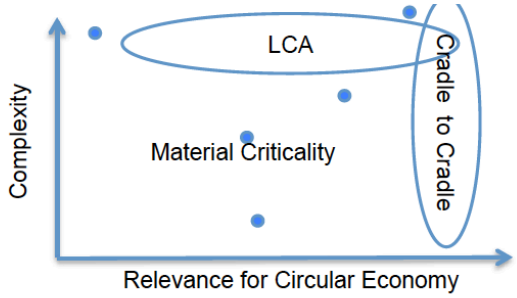
3. **'The curse of the status quo':** (re)doing the things we have always done is a human trait that afflicts both companies and consumers. On company side, it is easier to keep going with the resulting flow originating from decisions that were made in the past (especially if they have proven successful) rather than changing course, especially when risks and costs are high and there are no proven roadmaps. On consumer side, considering the purchase of, e.g., a more expensive product that could possibly last longer and embed better value, or even to consider leasing (or sharing) instead of owning, can be a daunting proposition (Nguyen *et al*., 2014).

### *3.2.6 Measuring circularity*

There are no recognized tools or indicators to measure the transition towards product or company circularity (Ellen MacArthur Foundation *et al.*, 2015b). Currently, the EMF and Circle Economy are the two main organizations that have published complete or partial information on circularity measurement. Their publications on the subject are presented in the following paragraphs. It should be noted that this area of CE would likely expand in the coming months and years.

#### *Measuring circularity according to the Ellen MacArthur Foundation*

The EMF's stakeholders have identified LCA and Cradle-to-cradle as possessing useful, but incomplete, indicators for circularity measurement design. Figure 3-9 illustrates the mapping of how they view the relevance of these types of indicators compared to 'material criticality' indicators.




SOURCE: Circularity Indicators Team; Circularity Indicators Stakeholder Workshop May 2014

**Figure 3-9: Stakeholder perception of existing indicators.**

From: Ellen MacArthur Foundation *et al.* (2015b), p. 7

According to the EMF and Granta Design (2013), the quantification of material flow restoration and a Material Circularity Indicator (MCI) are viable avenues, as they can theoretically measure something akin to 'systems thinking'. The MCI indicates the quantity and intensity of materials circulation but cannot inform on the nature of the materials and lacks the ability to inform on product impacts. Figure 3-10 explains the MCI input/output logic.

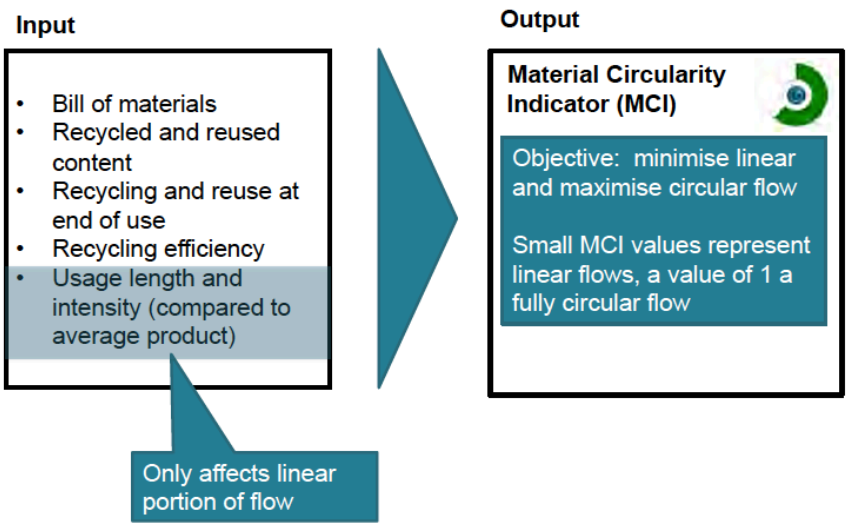



**Figure 3-10: MCI input and output model.**

From: Ellen MacArthur Foundation *et al.* (2015b), p. 13

The main challenge is to aggregate several indicators into one main "circularity indicator". Figure 3-11 illustrates the demarcation between existing indicators and the CE indicator(s) that must be created and used in order to measure a company's transition towards circularity.

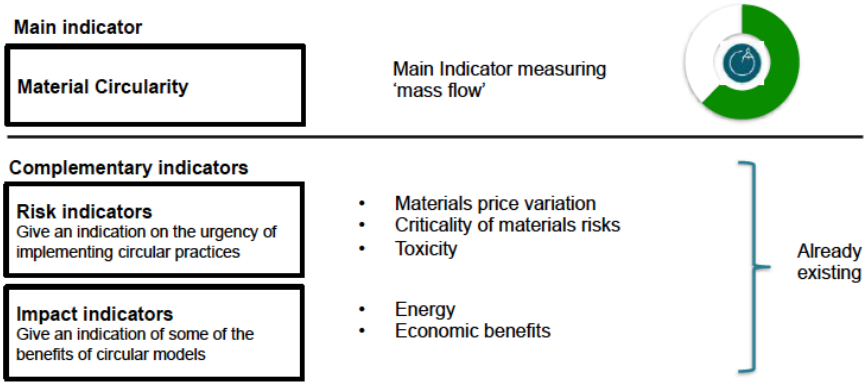



**Figure 3-11: Demarcation between existing indicators and those to be defined.**

From: Ellen MacArthur Foundation *et al.* (2015b), p. 9

The EMF in association with Granta Design (with funding provided by LIFE[8]) have published in May 2015 an indicators project overview as well as the associated methodology. The indicators were pilot-tested with 8 companies (CHEP, Cisco Systems, Desso, Dorel, Hewlett-Packard, Kingfisher, Nespresso and Rolls Royce). Discussions about the methodology were conducted with an array of 30 stakeholders from the

[8] LIFE is the EU's financial instrument supporting environmental and nature conservation projects throughout the EU, as well as in some candidate, acceding and neighbouring countries (Ellen MacArthur Foundation, 2015c).

investment, higher education, public, private and NGO spheres and were peer-reviewed by 12 specialists operating within public, institutional and private organizations.

The circularity indicators have been developed at product and company levels and a web-based tool at product level has been developed[9]. The scope of the indicators is narrower than what CE stands for (i.e.: systems thinking) and focuses on restoration, based on 4 principles: reused or recycled inputs; components reuse or postconsumer recyclability; longer life; product use intensity. The indicators focus exclusively on technical nutrients and their inherent cycles.

Product level indicators calculate material input, use length and intensity and waste (Ellen MacArthur Foundation *et al.*, 2015b). Company level indicators are based on the assumption that it is possible to aggregate multiple products' MCIs and use this aggregate performance as proxy for company circularity evaluation. The methodology calls for use of reference products, which represent a range of similar products (Ellen MacArthur Foundation *et al.*, 2015b). A spreadsheet tool is provided in order to aggregate multi-products as well as some guidance on normalizing factors for individual products' weight within a general portfolio (revenues, product mass, raw materials costs, etc.). The aggregation methodology is illustrated at Figure 3-12.

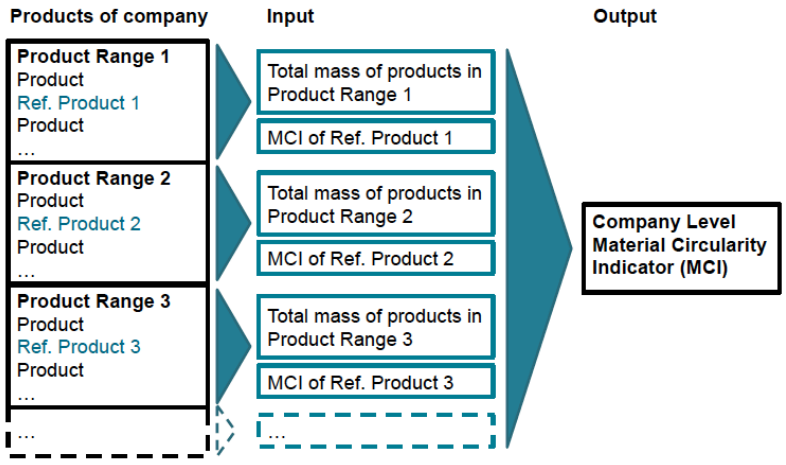



**Figure 3-12: Company level indicators computation.**

From: Ellen MacArthur Foundation *et al.* (2015b), p. 19

### *Product level MCI*

A product's MCI measures linear flow minimization as well as restorative flow maximization, and compare it to a similar industry-average product. It is built using three product characteristics:

1. The mass $V$ of manufactured virgin raw material
2. The product's mass $W$ of unrecoverable waste
3. A utility factor $X$ that accounts for the product use's length and intensity (Ellen MacArthur Foundation *et al.*, 2015a).

[9] Granta Design has developed this web-based tool, called MI:Product Intelligence, which can be used through the MI:BoM Analyser or the MI-Materials Gateway interface via a CAD system (Ellen MacArthur Foundation, 2015c).

The MCI's associated material flows are presented in Figure 3-13.

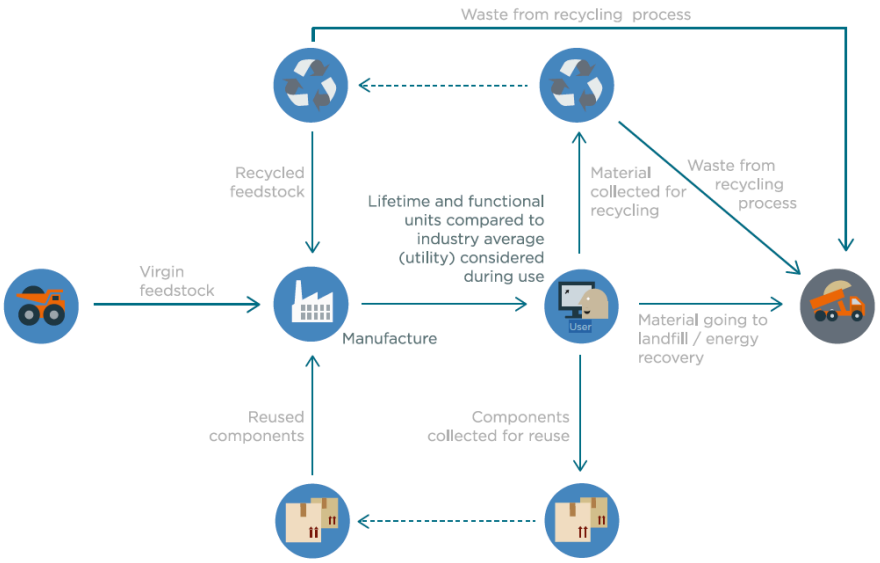



**Figure 3-13: Circularity indicators materials flow diagram**

From: Ellen MacArthur Foundation *et al.* (2015c), p. 5

Data is provided using a bill of materials (BoM) for materials and components and should provide the following information:

- **Production process input:** basically in order to determine virgin and recycled/reused components.
- **Use phase utility:** determines use intensity and increased durability (including repair ability and maintenance) compared to industry average for similar products.
- **End-of-life destination:** this information helps in ascertaining landfilling or energy recovery rate as well as recycling or reuse rate.
- **Recycling efficiency:** this type of information is used to reveal recycling processes efficiency for both inputs and post-use (Ellen MacArthur Foundation *et al.*, 2015b).

Using this logic, a product manufactured using 100% virgin material and landfilled at the end-of-life stage would be a fully 'linear' product that would score 0, while a product made only with second life materials and would also be collected for recycling or reuse at end-of-life would be a fully 'circular' product and would score 1. In practice however, most products would fall somewhere within 0 and 1 (Ellen MacArthur Foundation *et al.*, 2015a).

Complementary indicators, which seek to measure business and environmental risk such as price variations, material supply chain risks, material scarcity and toxicity, etc., are optional and meant to provide information that is usually and traditionally provided by a company's risk management dashboard. They can help in decision making by providing information on which parts, materials or products should be better managed as well as on business priorities. Typically, complementary indicators will be congruent with GRI-type indicators (Ellen MacArthur Foundation *et al.*, 2015c).

### *Company level MCI*

The company-level MCI is based on the hypothesis that products' MCIs aggregation (using a weighted average using normalising factors) equivalent to company MCI, introducing a *de minimis* rule

(established at 5% total mass shipped or total revenue) allowing the disregard for departments or products that have low contribution to overall company performance (Ellen MacArthur Foundation *et al.*, 2015c).

Some limitations with MCI methodology have been presented, namely that apart from the circularity principle, other impacts (aside from the complementary indicators) are not properly taken into account. Thus, complementary approaches are suggested in combination with using MCI, namely, LCA. Life cycle indicators present commonalities and differences with MCI and can be used in a complementary fashion. Another interesting point is that at least some (if not most) data needed for LCA is similar to that necessary to calculate MCI. LCA focuses on impacts throughout the product's life cycle and can be comparative, whereas for now, MCI analyzes only material flows throughout the use and end-of-life phases for one single product. Therefore, an ecodesign approach could combine, e.g., LCA and MCI indicators (Ellen MacArthur Foundation *et al.*, 2015a).

### *Measuring circularity according to Circle Economy and PGGM*

Circle Economy and the Dutch pension fund PGGM (2014) aim to create a Circularity Assessment based on absolute sustainability assessment (ASA), meaning that relative measures are given up to the profit of measurement which takes planetary limits (biophysical, economic, and societal) into consideration. The aim of this mode of assessment is to show at a glance a company's level of circularity stewardship, so investors can relate it to fiscal risk (Circle Economy and PGGM, 2014). In the consulted literature, this assessment framework seems the most complete and coherent with CE principles.

The first CE assessment draft is based on three levels of indicators, namely: materials, products and company. For materials, a list of circularity factors has been developed to determine the priority level of materials in CE. They are: depletion, pollution, hazard, biodegradability, interaction potential or by-products concern, renewability, potential recyclability, recycling input intensity, available reserves, current rate of consumption, scarcity, competing demand and available substitutes. These factors are weighted against 3 types of risk:

- Recycling priority
- Material risk
- Scarcity risk

The materials factors are visually represented by Figure 3-14.

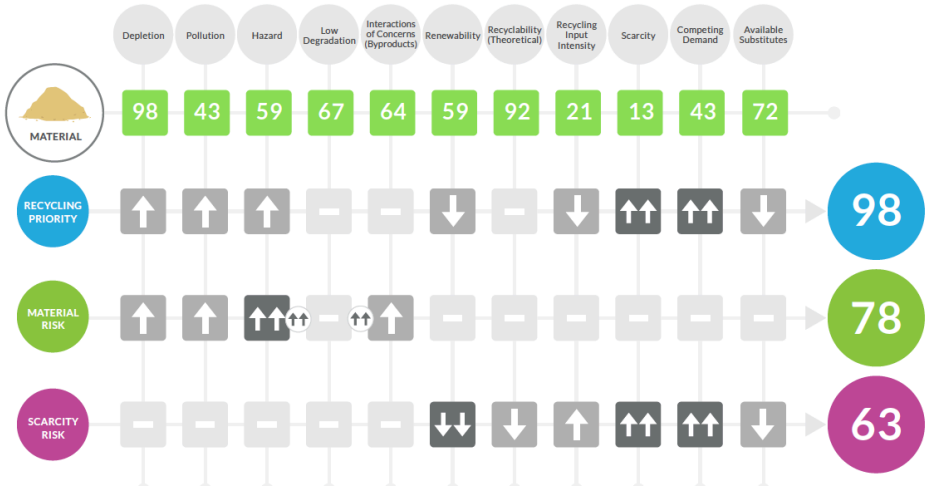



**Figure 3-14: Materials factors in a circularity framework.**

From: Circle Economy and PGGM (2014), p. 10

Products are classified according to 3 categories: consumables (biological nutrients), non-consumables (technical nutrients) and infrastructural, as presented at Figure 3-15. Each product category has its own range of factors, e.g.: complexity, life span, ease of disassembly, etc.


**Figure 3-15: Products classification in a circularity assessment framework.**

From: Circle Economy and PGGM (2014), p. 11

The last assessment level concerns systems, i.e.: business models, logistics, planetary boundaries and ethical allocation data. This assessment is based on value judgement based on assessments such as the Planetary Boundaries report by the Stockholm Resilience Center. The assessment is composed of 4 key indicator categories, each divided in direct and indirect impacts, which evaluate organizational resource throughput:

- **Planetary Boundaries:** consist in environmental indicators that aim to reflect a company's direct and indirect effects on key aspects of the biosphere's functions.
- **Economic Risk:** these indicators evaluate a company's reliance on scarce or unstable resources, threatened either by humans or the biosphere's boundaries
- **Smart Use:** this indicator category assesses organizational management of resources (material, energetic, ecological, and human) involved in delivering a product, or service
- **Ethical Allocation:** this category of indicators has to do with the « fair share » principle relating to "inter-cultural, inter-generational, and inter-species equity" (Circle Economy and PGGM, 2014, p.15).

Each category is further subdivided into subcategories that are relevant for each direct or indirect category impact. Direct impacts are those that can be attributed to the company while indirect impacts are related to broader effects (Circle Economy and PGGM, 2014). The system level assessment framework is presented at Figure 3-16.

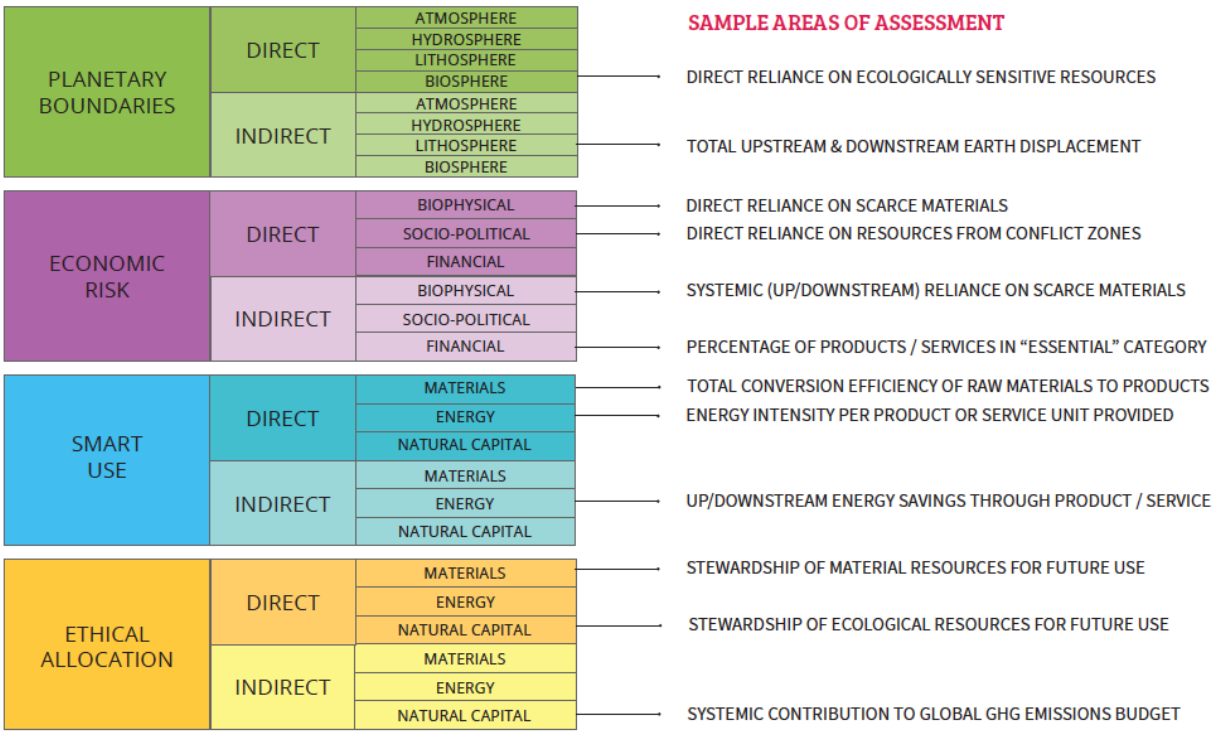



**Figure 3-16: System level indicator overview.**

From: Circle Economy and PGGM (2014), p. 17

### *3.2.7 Discussion and key takeaways*

The scale of CE implementation cannot occur at one level only; it is a multi-level system that needs the cooperation of government, civil society and private actors in order to be successful. While this is understandable, it can also create a strong obstacle, as coordination is a major element to achieve in order to attain circularity. Therefore, CE needs to be explained and spread to various national governments, rolled out to regions and cities and private economic actors need to be on board as well.

Since the 1990s, several legislations worldwide have conceived of and implemented more or less complex versions of CE. To date, China is the only country that has adopted a specific CE law, in 2008. China's brand of CE is based on scientific theory but also on Chinese traditional beliefs, creating a unique perspective the 'harmonious society'. However, China's macroeconomic CE implementation can generally be considered large-scale industrial ecology. The European Commission, in order to prepare an arguably more ambitious and tailor-made package, which should be presented to the members in the course of 2015, has recently deactivated a CE package. In the Netherlands, a first roadmap for regional and national implementation has been produced, containing steps to attain CE and projected obstacles to overcome. This roadmap is useful and can also serve for companies to plan ahead and create early partnerships, which could ensure a competitive advantage.

Pertaining to business, various elements and principles have been established for companies to adhere to CE. Business models have been carved out and disruptive technologies have been identified. These are not new, coming from various key associated concepts (mostly Functional Economy) but their compendium serves to present an attractive showcase for companies, who must then judge if there is a fit between their current business proposition and CE business models.

CE measurement is also underway in more or less mature states. The EMF's circularity indicators methodology and web tool are designed on a product and company level, with company level evaluation based on a sampling of reference products performance, aggregated using characterization factors. The framework is based on a main MCI with complementary indicators pertaining to issues such as price variations, material supply chain risks, material scarcity and toxicity, etc. Data is provided by a BoM, creating a quantifiable and credible method that should garner acceptance from many possible adherents. However, as it focuses solely on restoration and fails to address other core CE issues, such as systems thinking. This could (and should) be part of future developments.

Circle Economy and PGGM's assessment method, which is less developed to date in terms of operationalization, takes a more holistic point of view based on adherence to ASA principles. The assessment framework is based on material, product and system levels, whereas materials are evaluated against a certain number of factors, which permits product classification. Organizational resource throughput is evaluated against planetary boundaries, economic risk, smart use and ethical allocation, introducing evaluation principles that take into account more than simple BoM data, but also introduce uncertainty and a larger research agenda for the method to come to fruition. The systemic level of assessment is scored against absolute boundaries and based on value judgment, which may make this tool less robust in a quantifiable (i.e.: arguably less challengeable) perspective. Both these assessment methods, however, do not take impacts properly into consideration, including possible shifts between life cycle stages, environmental issues or eventually stakeholder categories, if the methodologies ever take the social dimension into consideration. This is problematic, but could potentially be addressed by a complementary LCA assessment, therefore integrating efficiency into effectiveness based model.

# 4 Positioning and mapping the concepts

After having defined a number of key concepts that can be associated with CE as well as the state of the art on CE conceptual knowledge, a positioning of these concepts, in relation to CE but also among themselves, is attempted in chapter 4. The concept positioning is done using 3 types of mapping, used to bring a specific perspective based on various discriminating aspects.

## 4.1 Methodology

The general aim of the two proposed mappings is to create enough discriminating variables and parameters as to be able to discern how concepts are different, or the same, and to what degree. It was understood that this critical literature review had to be useful, give an idea of how CE and its related concepts would position themselves against a larger conceptual/applicability view and also how the various concepts would relate to CE's tenets. Based on the previous, the two mappings are:

1. **Scope and concreteness mapping:** made to explain very briefly and visually the positioning of the various concepts in a simple way, this mapping is based on a 2 axis matrix that each evaluates different elements, from micro to macro. The 'y' axis presents a scope of application scale from 'company level' (micro) to 'society/planet level' (macro). The 'x' axis presents a concreteness gradation from 'tools' (micro) to 'philosophy' (macro).
2. **EMF circularity thinking mapping:** this mapping positions each concept against the 5 main pillars of CE according to the EMF, in order to make their ties more obvious.

This positioning was done internally at the ILC Chair and is based on existing knowledge and on expert judgement. As most concepts are multidimensional and evolving and present room for interpretation, some subjectivity remains in this analysis. In order to minimize potential bias and improve neutrality, five individuals of the ILC Chair were involved in the positioning. Furthermore, the mapping aims at coherence and usefulness, rather than presenting an absolute truth.

It should be noted that social and societal aspects (such as equity, job creation, etc.), the user/consumer's place in CE as well as other considerations are not included in this positioning exercise, and are considered to be lacking in order to fully understand all the implications of CE and its associated concepts.

## 4.2 Scope versus concreteness mapping

Figure 4-1 below presents the positioning of the various concepts according to 2 scales:

- Scope (Y-axis): The lower end of the axis signifies that the concept relates to an implementation or a vision at a single company's level, while a concept located at the higher end relates ultimately to society at large. Intermediate levels are also positioned along the axis in order to illustrate the continuum: "multiple companies", "value chains" and "global economy". The "value chains" level can include companies directly involved in the production processes, but also local communities involved or affected by these processes.
- Concreteness (X-axis): This axis presents to what extent the concept gives concrete indications for implementation. This axis is also a continuum, illustrated by the following steps: "tools" (most concrete way to guide implantation), "procedures", "framework/guidelines" and "philosophy". The last step corresponds to a concept which gives a general idea or vision as to

how society – or parts of it – should implement the concept, but does not directly give practical indications regarding implementation of this idea or vision. Certainly, most concepts at the "philosophy" level can give birth to implementation concepts, but the concepts do not intrinsically carry an implementation manual.

These two scales or parameters are indicators of *how* the concepts can be put into action but do not give information on their respective *content* in terms of what aspects of sustainable development are included or of what kind of actions or leverages are promoted.

Figure 4-1 aims to enable the understanding of the differences and similarities among the studied concepts, according to the parameters "scope" and "concreteness".

When interpreting this mapping, it is important to keep in mind that:

- The mapping is based on two parameters and does not offer a complete comparison: two concepts located on the same spot on this graph are not identical or equivalent, but are characterised by a similar degree of concreteness and a similar scope.
- Interpretation of ellipses: areas were used rather than dots to position the concepts because most of them present a certain level of variability regarding their concreteness and scope. The fact that an ellipse is larger than another purely reflects a larger variability regarding these two parameters. Overlaps between ellipses or inclusions of one ellipse into another should not be interpreted in terms of *content* of the concepts (e.g. "industrial ecology is a sub-assembly of performance economy": wrong).

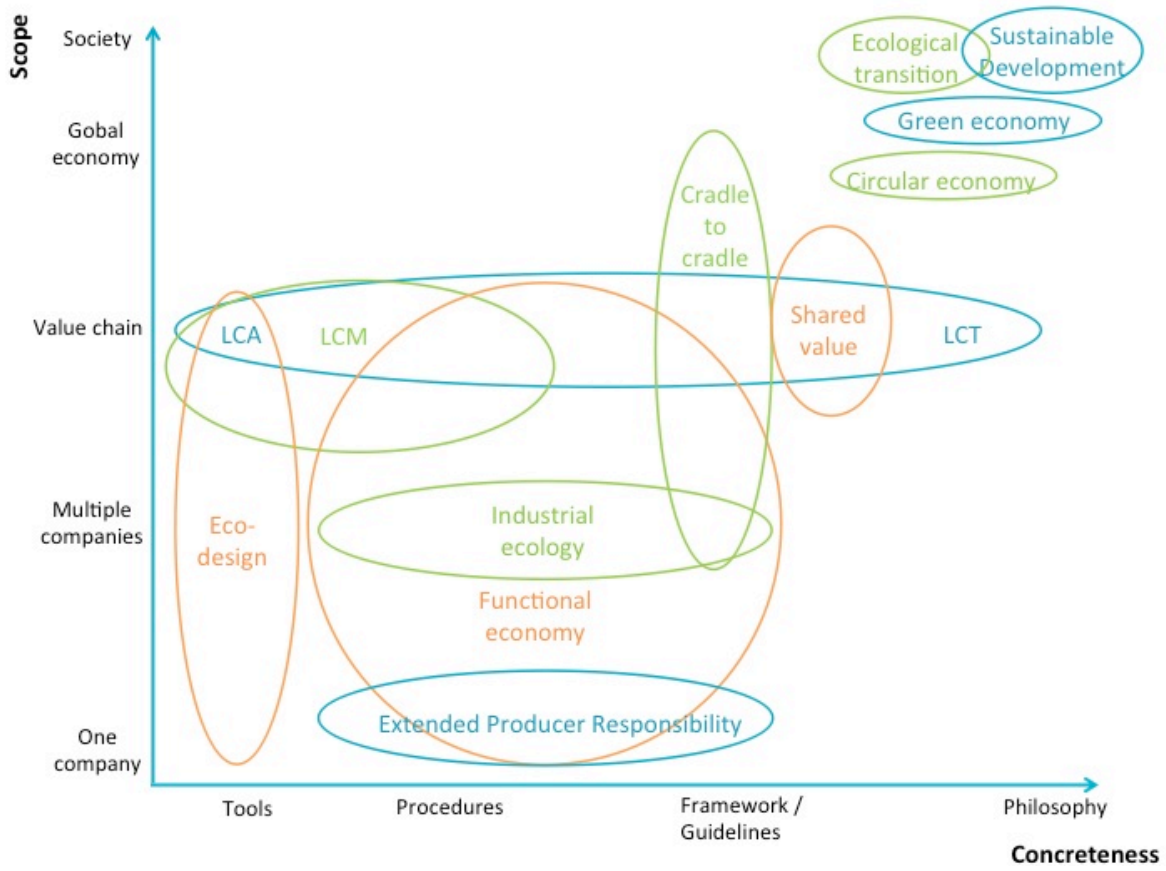



**Figure 4-1: Scope versus concreteness mapping.**

Note: Colors are used to facilitate the association of an area with its name but do not have a signification.

The mapping clearly illustrates that the examined concepts represent a wide array of realities in terms of the scope they cover and of in how far they guide the users into their practical implementation. As can be seen, the concepts are roughly positioned along a diagonal, reflecting the general idea that the larger the scope of the vision carried by the concept, the less concrete the concept is regarding its implementation. The discussion below roughly follows this diagonal, starting with the top right end.

### 1) Sustainable Development, Ecological Transition, Green Economy, Circular Economy

These four concepts lie close to each other on the mapping, reflecting the fact that they all propose a high level vision for (parts of) society.

Regarding the scope scale (Y-axis), Green economy and Circular economy lie lower than the other two concepts because their focus is the economic actors within the society. CE lies even slightly lower than green economy as it has a stronger focus on value chains, though ultimately aiming to bring about a global economic system paradigm shift. Sustainable development and ecological transition lie at the highest end of the axis, as they explicitly target society at large in their vision, and not only economic interactions.

Regarding the concreteness scale (X-axis), all four concepts correspond to the "philosophy" level as none of them offer – in their essence – guidelines regarding their implementation. CE lies slightly more

to the left as the idea of circularity – at its core – gives a rough direction regarding the "how". Again, it is important to keep in mind that this evaluation is based on core conceptual tenets, and not on implementation literature linked to them. For example, ecodesign could be an implementation of any of the four concepts, but it is up to practitioners to decide in which higher-level operationalization view they locate their efforts.

### 2) Shared Value

Shared Value has a focus on value chains and local communities. It gives a general framework but implementation is generally left in the hands of companies, which means strategic implementation is not put into action according to a coherent framework and does not enable comparison between companies. Depending on the depth of its implementation, Shared Value can be far reaching and co-exist with, e.g., SD and CSR and enable comparison using the Global Reporting Initiative (GRI). It is very value chain-centric but could potentially span more than the value chain, thus its height that overflows slightly the value chain. Since it is (by design) not a prescriptive approach, it is situated somewhat as a more general position than frameworks/guidelines, but not quite at the philosophical level, as it does contain some indications of operationalization.

### 3) Cradle-to-cradle

The higher end of the ellipse relates to the fact that C2C thinking envisions an economy where all material inputs and outputs are seen as technical or biological nutrients; global economy becomes essentially waste free. This vision gives a framework on how to achieve this, i.e. by redesigning production systems as closed loops. In practice, the concept gives guidelines to be applied at the "multiple companies" or "value chain" level, even though the tool that is mainly used is the Cradle-to-cradle certification (for products).

### 4) Life Cycle Thinking, Life Cycle Management and Life Cycle Assessment

Life Cycle Thinking is a mindset or posture ("philosophy" level) that implies looking at the complete value chains, away from the focus on individual performance. LCT is put into action through LCM, which can be seen as a business management approach or as a toolbox. Specific tools also exist, such as LCA (environmental, social or economic). The focus is always on the life cycles, or value chains.

### 5) Functional Economy

This concept presents a new vision of companies' and governments' roles on the path towards a sustainable economy. Furthermore, it also gives more precise guidance for implementing concrete business models (e.g. selling services instead of products). Applications relating to performance economy can be implemented by one company on its own or can involve several actors of a value chain.

### 6) Industrial Ecology

Industrial Ecology's goal is that industries work together in order to move from a linear to a cyclical or closed loop system. The concrete implementation depends on the specific context, but the concept offers a clear approach regarding how to study the industrial system in order to find sound solutions. By definition, Industrial Ecology involves more than one company. These companies are generally physically close to each other so as to be able to exchange flows of energy or materials; there are hence not *per se* parts of the same product chain.

### 7) Extended Producer Responsibility

Extended Producer Responsibility is, in theory, applicable to single companies although its implementation can require collaboration with similar companies (not parts of the same value chain) and other stakeholders (e.g. for implementing a large-scale take-back and recycling system for all

WEEE). The concept is mainly put into action through policies, giving incentives, guidelines and objectives to companies of some specific sectors.

#### 8) Ecodesign

Ecodesign allows the integration of environmental consideration into product development. This is a very practical concept, available under various forms, such as checklists or analytical tools. Its application is mostly at product level, but it can involve the value chain through the integration of LCT. MNEs will often implement after, or in conjuncture with LCA, e.g. Nestlé which has built an ecodesign tool, EcodEX, in order to reduce the number of LCAs performed and enable various Nestlé product managers and designers to assess products and facilitate R&D (Schenker *et al.*, 2014).

### 4.3 EMF circularity thinking mapping

This mapping explores the extent to which CE's principles are present in the associated key concepts' definitions. For each principle, the authors evaluated whether the idea behind it lies at the core of the examined concept, whether it is simply present, at the margin or absent. When a principle can be a consequence of the concept application but is not part of the concept's definition, it was marked as "absent". A score is given to rank the concepts according to their adhesion to the CE principles (score = sum of stars). CE is not analyzed with the other concepts, since it forms the reference according to which the analysis is performed. Results are presented in Table 4-1.

**Table 4-1: Circularity thinking mapping based on the pillars underlying the Ellen MacArthur Foundation definition**

| | Systems thinking | Waste is food | Design out waste | Diversity is strength | Renewable energy | Score |
|---|---|---|---|---|---|---|
| **Sustainable Development** | ★★★ | -- | ★ | ★★ | ★★ | 8 |
| **Ecological Transition** | ★★★ | -- | -- | -- | ★★ | 5 |
| **Green Economy** | -- | -- | -- | -- | ★★ | 2 |
| **Functional Economy** | ★★★ | -- | ★ | ★ | -- | 5 |
| **Life Cycle Thinking** | ★★★ | ★ | -- | -- | -- | 4 |
| **Cradle-to-cradle thinking** | ★★★ | ★★★ | ★★★ | ★★★ | ★★★ | 15 |
| **Shared Value** | ★★ | -- | -- | ★★ | -- | 4 |

| | Systems thinking | Waste is food | Design out waste | Diversity is strength | Renewable energy | Score |
|---|---|---|---|---|---|---|
| **Industrial Ecology** | ★★★ | ★★★ | ★ | ★★★ | -- | 10 |
| **Extended Producer Responsibility** | ★★★ | -- | ★★★ | -- | -- | 6 |
| **Ecodesign** | ★★★ | -- | ★ | -- | -- | 4 |

Legend: Significance of the EC principles for the definition of the associated key concepts
Core: ★★★ ; Present: ★★ ; Marginal:★ ; Absent: --
Score = number of stars

This mapping shows that all CE principles are present in the associated key concepts, with varying intensity. Generally speaking, the "systems thinking" principle is the most commonly shared between all concepts, pointing to a now generalized recognition that sustainable development challenges need to be tackled at a system level. Second comes "diversity". "Renewable energy", "waste is food" and "design out waste" come together as third.

Concepts are discussed below by decreasing order of score.

1. **C2C thinking** shares the same core principles as CE or, which would be chronologically and conceptually more appropriate, CE embraces the principles of C2C. This strongly illustrates that C2C lies at the heart of the development of the CE concept.
2. **Industrial Ecology** shares most CE principles, mainly the "systems thinking", "waste is food" and "diversity" principles.
3. **Sustainable Development** was particularly difficult to assess, as its numerous incarnations tend to merge with its original definition. Besides, the "true" definition of sustainable development is still debated. Yet, with the support of a few founding texts, it was assessed that sustainable development includes the following principles:
    a. Systems thinking: strong links have to be made among the three spheres (social, environmental and economic) and between current and future generations.
    b. Diversity is strength: Protection of biological diversity is central in the outcomes of the 1992 Rio Conference (specific Convention and Agenda 21). Cultural diversity is also present, notably in the Agenda 21 under the recognition of the vital importance of a genuine involvement of all social groups for successful implementation of Agenda 21 policies and initiatives. The Johannesburg Declaration on Sustainable Development (2002) also reaffirms that our rich diversity is our collective strength.
    c. Renewable energy: The renewable character of resources, among which energy resources, is key to the inter-generational equity put forth by SD.
    d. Design out waste: "States should reduce and eliminate unsustainable patterns of production and consumption" (*Rio Declaration on Environment and Development*, 1992)
4. **Functional Economy** necessitates systems thinking, as this concept implies redesigning value chains and value creation in order to maximize resource use efficiency. Diversity is present in the concept as the need for complementarity among actors. Finally, waste is seen as the "inability to use goods longer".
5. **Ecological Transition** was also difficult to assess since it is a very multidimensional concept, with a variable and still evolving content. It was assessed that systems thinking is an important feature, as

the concept focuses on transition processes, including the numerous interactions occurring along the way. Besides, as the concept is often used in a context of energy or low carbon policies, as for instance with the associated term “transition towards a low carbon economy ", it is assumed that the “renewable energy” pillar is also marginally present.

6. **Life Cycle Thinking** has systems thinking at its core, the system here being the product or service life cycle. The idea of closing the loop through recycling is also present.
7. **Ecodesign** embodies the idea that the very upstream design phase influences all the downstream steps of a product life cycle. “Design out waste” is often notable feature.
8. **Shared Value** focuses on value chains, hence a notion of systems.
9. **Extended Producer Responsibility**: The original definition of the concept by Lindhqvist includes systems thinking by extending a producer’s responsibility through the whole life cycle of its products (though its implementation largely focuses on end-of-life stages). “Design out waste” is also evaluated as being very much present, as this is the main objective for giving back the ownership of a product’s end-of-life to the producer.
10. **Green Economy**’s focus is essentially not on CE principles. Promotion of “green technologies” – which is important for green economy – can be related to the “renewable energy” principle.

It is interesting to note that the Ecological Transition and Green Economy concepts, which presented a position similar to CE on the scope/concreteness mapping, only yield very low scores with the circularity-thinking mapping. There are hence significant differences in the definitions of these concepts, though they can again meet on the ground of concrete applications.

## 4.4 Key takeaways

The key takeaways are formulated as comparisons of each concept with CE, based on the two mappings above but also on the explanations given in Chapter 2.

### *Sustainable development versus Circular Economy*

Sustainable development and Circular Economy are both high level concepts – though SD is wider – presenting a vision for society at large or for the global economy, respectively. Circular Economy is somewhat more “concrete”, in that it gives a framework to guide action at business level.

Some organizations, namely Amsterdam based Circle Economy and Metabolic, have developed a set of circularity datasets which aim to connect high level objectives with daily business decisions all within a circularity framework. What are these high level objectives? None other than those that also appear in most SD literature, namely: ensuring the continuity of life on earth by adopting appropriate stewardship in order to contribute to flourishing ecosystems (natural as well as human), using an ethical perspective (Circle Economy and PGGM, 2014).

### *Ecological Transition versus Circular Economy*

Ecological Transition is a wider concept than Circular Economy, as CE can be seen as one of the many forms or directions that this “transition” can take.

### *Green economy versus Circular Economy*

The two concepts present wide areas of overlap in their concepts and implementation. Both aim to re-orient the economy at large towards environment-friendly products, services and processes. Both place economic actors at the center of their concept as economic activities are the leverage they use towards “sustainable development”.

There are also important differences, namely: 1) as a concept carried by large international organizations such as the UN, Green Economy includes poverty eradication and general development of countries among its objectives; 2) for its part, CE is more precise as to which economic systems or business plans are to be pursued.

Some specific activities can hence be seen as applications of both concepts (e.g. Functional Economy initiatives), while others not (e.g. the carbon market, which fits well into the Green Economy but not in CE).

#### *Functional Economy versus Circular Economy*

According to Stahel, CE is firmly rooted in the Functional or Performance Economy and, it might even be said, is one of the core strands of its DNA (as are C2C and Biomimicry). One of the strongest juncture points is the focus on longevity and intelligent waste-as-input management, propelled by innovation and new business models. One might say that the Functional Economy is the skeleton of CE while also being a fairly thorough roadmap to its implementation.

Pillars such as diversity and "design out waste" are more or less integral parts of Functional Economy, with an added sense of business and competitiveness. Like CE, the Functional Economy aims to decouple growth from resources depletion and introduces strategic points that need to be addressed (namely: the role of states) in enabling values chains to become more circular.

Functional Economy goes further than CE by its focus on jobs creation, based nevertheless on the same basic principle: care and appropriate stocks management. Both Functional Economy and CE coalesce on the question of the great structural changes that need to occur in order for CE to take root (Stahel, 2013a).

#### *Life cycle thinking versus circular economy*

Two major conceptual differences can be highlighted between LCT and CE:

1. LCA tools aim to evaluate a product or service's impacts over its life cycle and to identify hotspots and improvement opportunities. In this sense, LCA can be seen as giving a relative measure of sustainability: which option/life cycle stage/etc. performs *worse or better* regarding environmental, social and economic potential impacts. It is more difficult to position CE on this topic, as this concept encompasses multiple concepts and dimensions, but mostly because its basic assumptions is that absolute sustainability assessment (ASA) should be the cornerstone. C2C thinking, also at it CE's core, has a definite ASA approach, i.e. "is this product/option/etc. sustainable or not". Both approaches present strengths and weaknesses (Bjørn and Hauschild, 2013).
2. LCT tools focus on *impact* assessment and ultimately on resource efficiency, while CE focuses on principles that are primarily oriented towards resource effectiveness. There are hence opportunities for interesting complementarity between both approaches.

#### *Cradle-to-Cradle thinking versus Circular Economy*

C2C thinking is at the very heart of CE. Circular Economy's main pillars are directly taken from C2C: waste is food, systemic thinking, etc. CE's vocabulary (e.g.: nutrients, metabolism, etc.) is also directly infused by C2C, as is the difference that the EMF makes between eco-efficiency and eco-effectiveness (see section 3.1.1). It is clear that C2C deems itself incompatible with life cycle thinking, although its very name is taken from LCA's core vocabulary. It is however true that C2C focuses more on absolute sustainability and on effectiveness, rather than on efficiency and on relative performance. One may wonder whether this "linear determinism" put forward by Braungart and McDonough is a fatal flaw, or if simply, LCA could evolve its way of thinking in order to address absolute sustainability.

C2C is basically a design strategy that acts as the driving belt between Industrial Ecology and Functional Economy. Its IMP concept takes root partly in Industrial Ecology, but also lengthens the loop by including the downstream part of the value chain, designing a life cycle-like loop to make it circular. It is also interesting to note that CE takes in C2C's view of the eco-efficiency/eco-effectiveness dichotomy while watering down the strong language Braungart and McDonough use to distance them from eco-efficiency and, by proxy, from LCA. It is also noteworthy that for them, equity is a mere side effect of efficiency and not "an environmental necessity", suggesting an ecocentric approach which *de facto* excludes the social dimension of sustainability.

### *Shared Value versus Circular Economy*

Shared Value is conceptualized as a management approach that is opposed to both SD normative mechanisms (encompassed by CSR approaches) and government involvement in business. It endeavours to map out the intersection between evaluative approaches and business strategy for profit making, thus proposing potential intermediate indicators between SD and strategic KPIs. The social/societal dimension is central to Shared Value, while the environmental dimension is a means to attain social goals and license to operate. In this sense, its ties to CE lie within the "new consumers/user" paradigm, as is innovation and disruptive technologies. There is a beginning of something that could resemble LCT but is actually closer to sustainable supply chain management in the value chain re-conception approach, but there are no rounded out new business models that are proposed, at least not in the literature that was consulted.

The timing of the emergence of the Shared Value approach is interesting (in a so-called "post-CSR" era and right about the same time as CE), in the sense that it calls for a "change in capitalism" (i.e.: a change of economic thinking and acting), and is therefore a sign that management and strategy gurus have identified a real need for "traditional" (one may even say: linear) business to change. The same can be said of CE, which rests on a premise that there are limits to ecosystems and that there exists a need to create new decoupling mechanisms, on both business and consumer sides. The change that is proposed by Shared Value is milder than the disruption proposed by CE and more in continuity with a new brand of SD or CSR, notwithstanding Porter and Kramer's disassociation with both concepts.

### *Industrial Ecology versus Circular Economy*

The concept and applications of Industrial Ecology fit well into the wider concept of CE. Indeed, Industrial Ecology encourages energy and material flows among industries in order to increase the efficiency of their use. Systems thinking and resource efficiency are central in both concepts.

### *Extended Product Responsibility versus Circular Economy*

EPR can be said to consist of the first attempt at a systematic closed loop system with a private actor focus, in accordance with legislative and economic instruments. However, its empirical focus on end-of-life fails to address upstream cost reductions and does not link well with ecodesign, although it should theoretically be a strong incentive to design or redesign products for better environmental performance.

### *Ecodesign versus Circular Economy*

Ecodesign is a tool that aims to implement environmental considerations into product design and is often used in conjunction with LCA. C2C is also a design approach inspired by nature, whose main ideas may affect not only products but also larger industrial systems. As with LCA, ecodesign as it is generally practiced today is primarily based on improving efficiency, and could (but is not explicit) about "rethinking the way we make things", as is C2C's primary goal. Thus, a design approach that would fuse

C2C and ecodesign, especially when it is based on LCA results, could serve to, e.g., avoid impacts displacement, while also creating opportunities for innovation disruptions.

## 4.5 Caveats

The main limitations associated with this positioning exercise are:

- The positioning was done internally at the ILC chair and is based on existing knowledge and on expert judgement.
- Most concepts are multidimensional and evolving and present room for interpretation. This gives room for variable positioning.

In order to minimize potential bias and improve neutrality, five individuals of the ILC Chair were involved in the positioning. Furthermore, the mapping aims at coherence and usefulness, rather than at an absolute truth. It is nevertheless important to stress that the knowledge scope and inevitable biases that are inherent to the individuals who were involved in the mappings have influenced the final results.

- Social and societal aspects (such as equity, job creation, etc.), the user/consumer's place in CE as well as other considerations are not included in this positioning exercise, and are considered to be lacking in order to fully understand all the implications of CE and its associated concepts.
- The analysis of other concepts (such as biomimicry) would bring an interesting light on CE.

# 5 Conclusions and perspectives

As has been seen, CE is a multi-level, socio-constructed concept that can either be considered a paradigm shift, a new toolbox, a conceptual umbrella or a portmanteau discipline. Many elements play in CE's favour as a concept that can contribute to reducing companies' impacts on planetary limits, to a level that would permit the attainment of a form of holistic and restorative sustainability.

As has been amply proven throughout this review, CE is an idea or concept that is currently being developed, with moving and adaptable content as well as blurred boundaries. There is no absolute definition, or truth, about CE that can be pinned down to it alone. It feeds from multiple, rich sources (C2C, Functional Economy, Industrial Ecology, etc.) and attempts to create a palatable framework that is attractive for business as well as acceptable to States – though challenging for both. Basically sprouting from the same source as sustainable consumption and production (SCP), it nevertheless differentiates and distances itself from adjacent fields that could be of benefit to its success. Whatever CE is, or should be, or eventually becomes, is the result of negotiated or adversarial social interactions, steeped in science as well as in marketing and lobbying activities.

As a response to resource scarcity and eroding profits, CE does an adequate job of integrating a business sense into varied academic and commercial approaches. As a united front fording ahead and branding itself as business' response to a global economic crisis, it manages to obscure, or in some cases obliterate crucial societal themes, namely equity, human rights, and poverty alleviation (in short: the social dimension of SD).

So, what is CE's added value? It offers an integrated framework to operationalize SD's core ideas, it gives a second (and perhaps, much needed) wind to useful concepts and great thinkers, and it packages it all in an exciting branding that is ambitious and unapologetic. Its strong – and quantified – business vision and impeccable marketing arouses interest from many different stakeholders; as well, many exemplary thought-leaders are endorsing CE. In short, it gives hope to the business community that an answer to the sustainability riddle has been found, a way to finally balance and fuse all three of the balance sheet lines. It is also a toolbox, a roadmap, a direction and a cheerleader.

Is it robust enough to stand the test of integrated case studies at all implementation levels? Can it play well alongside other concepts and approaches or is it stand-alone? Will it manage to integrate the social dimension or is it a die-hard ecocentric approach? Will it be possible, affordable and relatively simple to assess it and measure its progress? Is it enriching and propelling useful ideas or is it at best cherry picking, and at worst cannibalizing it's way towards conceptual supremacy? Is it a mirage or an idea whose time has come? Time, robust case studies and additional literature will certainly tell.

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# Appendix A:
# Synthetized Circular Economy associated key concepts

## Table A1: Synthetized Circular Economy associated key concepts

| Definition | Goal | Authors / Schools of thought | Application (sector, stage, scale, etc.) | Tools |
|---|---|---|---|---|
| **SUSTAINABLE DEVELOPMENT** | | | | |
| **"Meet today's needs without compromising tomorrow's"**<br>"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." | Ensure the continued existence of human societies, considering the finite nature of earth's resources | Gro Harlem Brundtland (1987) | All scales of application but more product oriented; all life cycle, focus on end of life | SD tools can be grouped within the CSR tools, which are too numerous to name |
| **ECOLOGICAL TRANSITION** | | | | |
| **"Towards living within our limits"**<br>Transformation process of society towards a more ecological model. Changes occur at the system level (versus incremental changes in prevailing systems) | Implement, accompany or study such transformative changes | 1) Reflective governance<br>2) Multi-level perspective<br>3) Transition management | Various | Examples of applications: Transition towns, transition management approach in the Fourth Dutch National Environmental Policy Plan (NMP4), mainly for energy |
| **GREEN ECONOMY** | | | | |
| **"Economy 2.0"**<br>Economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, | Focus is on<br>- resource efficiency<br>- ecosystem resilience<br>- people's well-being | United Nations, European Environmental Agency, etc. | At industry level as well as for the economy as a whole | Economic instruments (carbon market, investment in green techs, …) |

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| resource efficient and socially inclusive | | | | |
| **PERFORMANCE ECONOMY** | | | | |
| **"More from less"**<br><br>An economy in which producers retain ownership of their products and sell performance to consumers. | Reduce environmental stress caused by industry whilst encouraging innovation, resource efficiency and sustained growth. | Walter R. Stahel | Product stages; industry and territory levels | - Sustainable taxation/externalities internalization mechanisms<br>- New business models based on take-back, remanufacture, remarketing and renting/leasing principles |
| **LIFE CYCLE THINKING** | | | | |
| **"Visibility on the whole life cycle"**<br>Approach aiming at going beyond the traditional focus on production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle.<br>(Life Cycle Initiative, 2013) | Reduce a products resource use and emissions to the environment and improve its socio-economic performance through its life cycle.<br>Avoid burden shifting.<br>→ Improve eco-efficiency (Bjørn and Hauschild, 2013) | Various "schools" for LCA, not on the concept itself but on its implementation (methodological debates).<br>Some authors (LCA):<br>- Ruedi Müller-Wenk<br>- Olivier Jolliet<br>- Bo Weidema | At the product or company level<br>Considers all life cycle stages | Create information to support a decision-making process:<br>- LCA (environmental); Carbon footprint; Environmental Product Declaration; …<br>- Social LCA<br>- Life Cycle Costing<br>- Life Cycle Sustainability Assessment<br>Implementation in organizations: Life cycle management (LCM) |
| **CRADLE-TO-CRADLE THINKING** | | | | |
| **"Waste = food"**<br>"Systemic approach to product innovation that spurs the creation of truly beautiful, high-quality products, and transforms the production of consumer products into a positive force for society and the environment" | Create production techniques that are not just efficient but are essentially waste free. | William McDonough and Michael Braungart (2002) | All scales of application but more product oriented; all life cycle, but a focus on end-of-life | Cradle-to-cradle Certified Mark |

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| **SHARED VALUE** | | | | |
| **" What's good for society is good for business"**<br>"Shared value is a management strategy focused on companies creating measurable business value by identifying and addressing social problems that intersect with their business" | To respond to unmet social needs through products and services; to transform capitalism; to create the next wave of innovation | Michael E. Porter and Mark. R. Kramer | Product/services and value chains | Shared Value articles and reports; Shared Value consultancy services (FSG) |
| **INDUSTRIAL ECOLOGY** | | | | |
| **"Work together as one organism"**<br>Perspective that sees industries as man-made ecosystems that operate in a similar way to natural ecosystems, where the waste or by-product of one process is used as an input into another process. | Reduce environmental stress caused by industry whilst encouraging innovation, resource efficiency and sustained growth. | Robert Frosch and Nicholas Gallopoulos<br>Suren Erkman<br>Thomas Graedel<br>Roland Clift | Industry and territory level; production stages | Industrial symbiosis, eco-parks, … |
| **EXTENDED PRODUCER RESPONSIBILITY** | | | | |
| **"The producer is responsible for its product"**<br>Concept that shifts a product's environmental burden, over the while life cycle but with a string focus on end-of-life, back to producer who reflect this responsibility in the product's price. Governments are important in setting legislative boundaries and economic incentives. | Reduce environmental impacts all through the life cycle; enable strong end-of-life systems. | Some authors:<br>Reid Lifset<br>Thomas Lindhqvist<br>C. Kieren Mayers<br>Naoko Tojo | Company level | Various instruments: economic incentives, take-back schemes, advanced disposal fees, deposit-refund, a combination of upstream tax and downstream subsidy, standards, etc. |

| ECODESIGN | | | | |
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| **"Environmental design thinking"**<br>"Ecodesign focuses on the integration of environmental considerations into product development" | Focus is on reducing environmental impacts caused by products | Design for dematerialization; design for the environment (DfE); green design<br><br>Some authors:<br>- Victor Papanek<br>- Nathan Shedroff<br>- Conrad Luttropp<br>- Philip White, Steve Belletire and Louise St. Pierre (Okala) | Product level mostly, but can also include the value chain | - Guidelines<br>- Checklists<br>- Analytical tools |