RADICAL CIRCULAR ECONOMY

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Recently the Circular Economy (CE) concept has gained momentum in the Netherlands, propounding that environmental impact reduction can provide a significant positive economical impulse. The government, larger parts of the industry as a whole, as well as the construction industry, has warmly received this approach. At first sight the CE concept connects over two centuries of sustainability thinking together in a relatively seen rather coherent framework. So, CE in its constituent elements doesn't provide anything new. It is the economic framework uniting the elements, which makes CE a new and challenging approach. Insofar the Dutch construction industry is concerned, based on the extensive experiences of the authors over the past years, the CE concept gets a fragmented, incoherent and eclectic interpretation. In the paper, departing from the concept of the 'homo-economicus' (Mill, 1836), and the free market theory (Malthus, 1826) CE, is re-defined into 'Radical CE' attempting to constitute a CE theory and terminology, appropriate for the construction industry and addressing the core of the CE concept in terms of a sustainable industry and society, behaving as such because of economic incentives. Based on the concept of 'Radical CE', the paper describes and evaluates several CE cases. The paper concludes with some guidelines and strategies for implementing CE.

Keywords: Radical Circular Economy, Sustainability, Homo-economicus, Free market theory, Circular Economy theory, Cradle 2 Cradle, Raw materials, Environmental impact reduction.

INTRODUCTION

The current and future developments indicate that the demand for natural resources will radically increase due to the growth of the world population from 7 billion persons today to 9 billion in 2050 (UNEP, 2011). At the same time, 3 billion people will be added to the middle class (OECD, 2012). This will lead to an increase in consumption and by further use of natural resources at the current pace two similar planets will be required in 2050 to meet the needs and aspirations of the people (EMF, 2012). As our society and economy are constantly changing, the unsustainable process of production, which contains a take-make-dispose model, has not changed since the beginning of the industrial revolution two centuries ago. This unsustainable development has resulted in scarcity of raw materials, depletion and waste of resources, global warming, environmental pollution, greenhouse gas, climate change and unfair distribution of wealth (IPCC, 2013). McKinsey (2011) reported that 'resource-scarcity' risks are increasing, leading to more 'volatile prices.' Continuing 'business as usual,' will likely impose increasing threats to the environment, welfare, wellbeing, competitiveness, profits and business continuity (Wijkman, and Skånberg 2015). Moreover, recent debates have focussed on the challenges and complexities associated with meeting the resource demand (Barlow, 2013). Chatham House (2012) reported "new models are required to de-link rising prosperity from resource

consumption growth." Due to these current developments, the quality of life for many is in jeopardy (EMF, 2013).

The construction industry is an important economic engine and makes intensive use of resources extracted from the earth, which generates a significant amount of the earth's environmental pollution (UNEP, 2011; BAM, 2013). Change in the construction industry is urgently required because the construction industry consumes 40% of the natural resources (Roodman and Lenssen, 1995). This means each year, approximately three billion tonnes of raw materials (European Commission, 2014) and a further 40% of the total flow in the global economy are used in the manufacturing of building products and components globally (BAM, 2013). Moreover, the built environment is responsible for 40% of the total use of energy (UNEP, 2011; European Commission, 2014).

Recently the Circular Economy (CE) concept gained momentum in the Netherlands, propounding that environmental impact reduction through CE can provide a significant positive economical impulse, this following EMF's (2012) report produced together with McKinsey. CE, although it's dates back much earlier, since 2012 became rather popular within the industry at governmental levels and by the EU (DG Environment, 2014). Circular economy is assumed to boost innovation and to generate profits for businesses as supply chains are better managed. In turn companies will be less sensitive to price volatility of resources, and additionally, adapting CE will build longer and better relationship with customers (Kok, et al., 2013). The Ellen Macarthur Foundation and TNO estimated the combined benefits to be around €500 billion over a ten year period for the European Union (3,6% growth cumulative) and around €7 billion for the Dutch economy (1,4% growth cumulative over a ten year period as the Dutch already have much higher recycling rates than other European countries) (Bastein et al., 2013; ING, 2015).

CE can be defined as an economic system. Within CE thinking predominantly (-neo liberal vision) the economic system is assumed to result in a sustainable industrial production. CE takes the reusability of products and materials and the protection of natural resources as a starting point and pursues value at every stage of the system (TNO, 2013). In a CE, the aim is to maximize value creation in each link in the system hence products must be designed for ease of reuse, disassembly and remanufacturing or recycling to keep material flows circulating at a high rate. So to achieve true sustainability, CE pursue value through design of the reusability of products and raw materials, and the restorative capacity of natural resources (in terms of quality, property, function, range of use) without the materials entering the biosphere, unless they are biological nutrients. Additionally a fundamental part of the CE concept (following Stahels' (1976) thinking) is the transition from product consumption to product services.

SUSTAINABILITY AND CIRCULAR ECONOMY

At first sight the CE concept connects over two centuries of sustainability thinking together in a relatively seen rather coherent framework. Malthus ('An Essay on the Principle of Population') -and later on Marx- already in 1798, warned that population growth would exceed resource growth, leading to catastrophic checks on overpopulation. At the turn of the century, Arrhenius (1896) noted the phenomenon of 'greenhouse gas emissions' and the 'warming of the Earth. Boulding (1966) described

the earth as a '*closed system'* and illustrated that the economy and the environment are interlinked. The publication "The Limits to Growth" by Meadow et al. (1972) distributed by the Club of Rome led to a huge impact on public opinion. The publication, predicted the beginning of the 21st century resource depletion. Commoner (1971) suggested that economy should be remodelled to adapt the unbending "laws of ecology." Commoners' approach of material-loops, was further developed by Stahel (1976) introducing 'the Looped Economy'. In the 1980s, "Our Common Future," the report of World Commission on Environment and Development (WCED, 1987) radically influenced the modern view by defining the concept of sustainable development as a holistic concept (People, Planet, Profit), claiming that the environmental degradation is linked to social as well as economic developments. The Rio Summit (1992) again addressed the fact that we can no longer think of environment and economic and social development as isolated fields. From 1990s onwards, the perception gradually shifted away from single products and processes towards a more integrated, holistic systems thinking approach (Lyle, 1994; Lyle Center 2011). Benyus (1997) introduced the 'Biomimicry' concept, stating that nature's best 'ideas' needs to be imitated to solve human problems'. Industrial Ecology' was introduced in the 1970s, partly based on biomimicry thinking, and gained mainstream attention since 1990 (Frosch & Gallopoulos). Industrial Ecology adopts a systemic point of view and focuses on material and energy flows. Waste within industrial models and symbioses are linked to develop closed ecological loop systems within industries (Graedel, 2002). Cradle to Cradle' (C2C) was introduced by Braungart (1999) and since became a rather dominant concept. The 20th century remarked the further development of so called 'integrated theories'. Stahel (2006), continuing his earlier thinking, and created the concept of the 'Performance Economy' a concept based on usage instead of ownership; the ownership is kept by the producers and the user pays a fee for the performance of a product. Pauli (2010) introduced the 'Blue Economy' concept, which is a design philosophy, where the cascading system is developed to use the waste of one product as the input to create new cash flows.

Circular Economy

At first sight the CE concept connects over two centuries of sustainability thinking together uniting the various schools of thoughts. New however is the accent on sustainability in terms of economic profit for all as a core concept. CE is most often visualised in the 'circular system interactive diagram' also known as the so-called 'butterfly-diagram' (EMF, 2012). The system diagram shows how –raw or virgin-organic materials, and technical materials behave in different circles or 'loops' flowing through and constituting the economic system. Within the technical cycle, materials must remain within that circuit, by means of maintenance, re-cycling, refurbishing and re-use. In the biological cycle, the materials are returned to the biosphere or directly used as nutrient for new cycles by composting and anaerobic digestion through non-toxic, restorative loops. Essential in the butterfly model is the idea of Stahels' product service concept in which the ownership of materials stays with the suppliers responsible to keep them in the circles. CE assumes an economic system resulting in sustainable industrial production. So in comparison to traditional sustainability thinking CE proposes a certain reversal of means and goal. However, due to the variety of concepts applied to (re-) define the CE concept it has become difficult to correctly address the definition and identify the challenges and obstacles, as there is relatively little critical analysis of the concept (Barlow, 2013). At least, as far as the Dutch construction industry is concerned, the CE concept gets a fragmented,

incoherent and eclectic interpretation. Besides, there is a lack of solid theory and connected –empirical- evidence, in general and within the construction industry more specifically. The question at stake is, 'how do we know if CE works,' or 'how do we know what it is', if there are no common proven and accepted definitions and measurement scales.

The aim of this paper is to re-define CE into 'Radical CE', attempting to constitute a CE theory and terminology, appropriate for the construction industry and addressing the core of the CE concept. To achieve this, the concept and theories from the different publications and the extensive practical experiences of the authors over the past years are developed into a priori specification of constructs. This is the first step in Eisenhardt's methodology on theory-building. This method is assumed to be appropriate in the early stages of research on a topic or to provide freshness in perspective to an already existing topic (Eisenhardt, 1989). Although this type of specification is not common in theory-building studies to date, it is valuable because it permits researchers to measure constructs more accurately. If these constructs prove important as the study progresses, then researchers have a firmer empirical grounding for the emergent theory (Eisenhardt, 1989). As is typical for theory building, such approaches have to find a balance between generalization and specialization. Generalization makes them applicable in a wider range of settings. Specialization allows being detailed enough to yield insights on the individual case level. Next the constructs are thought through to identify opportunities, challenges, issues or obstacles. In this paper an attempt is made to measure new developed CE constructs in a few cases on building and product level within the Dutch construction industry.

RADICAL CIRCULAR ECONOMY

A priori constructs

Within Radical CE, CE is foremost seen as an economical system resulting in a more sustainable –industrial- production. Sustainability is defined as preserving the earth for future generations, with regard to global population growth, growing prosperity, social justice and fairness. The willingness of society to morally adapt this sustainability concept is axiomatically assumed within Radical CE. Radical CE departs distinguishing the *natural world* (mother earth with *raw/virgin materials* and natural resources), and an *artificial (man-made) world* with *materials/parts* (extracted from the earth), *products* (assembled parts) and *components* (more complex or and assembled products). Within the artificial world there are two *cycles* or *loops* namely a *biological* and a *technical* one. Within Radical CE in principle all materials stay as much and as long as possible, within one of the loops. Preferably as one can assume the regenerative capacity of the earth has its limits, materials have to be kept in the technical loop. Switching between the loops is part of CE. The technical materials that degrade during their period of use (lifecycle), or when they are no longer usable within the technical cycle, must be returned to the biological cycle (this assumes axiomatically that no CE materials without an economic CE act can be given back to the earth). In order to close cycles, energy is needed (Joustra et al., 2013). Within Radical CE axiomatically assumed there is an endless amount of clean energy available (EMF, 2012). The human within Radical CE is axiomatically a '*Homo-economicus*' (Mill, 1836), which assumes a particular 'theory of life' as the 'foundation of morals'. According to Mill, A homo economicus within a Radical CE "does not treat the whole of man's nature as modified by the social state, nor of the

whole conduct of man in society. It is concerned with him solely as a being who desires to possess wealth, and who is capable of judging the comparative efficacy of means for obtaining a wished end." Alongside, Radical CE is based on the *free market theory* (Malthus, 1826). This theory is based on a system where the forces of supply and demand are allowed to reach their point of equilibrium without intervention by government policy, and it typically entails support for highly competitive markets and private ownership of productive enterprises in which the prices for goods and services are set freely by consent between vendors and consumers. The *end-users or consumer* as 'Homo economicus' within Radical CE are not the (legal) owners of the products but they buy *services* in the form of a *user right* for a certain period of time. This means that consumers cannot, or only limited (only the services products contain), trade products. As due to scarcity, prices of materials will continue to rise this service concept is assumed to be in the benefit of suppliers as well as consumers. The *supplier,* as 'Homo economicus' within Radical CE always remains the owner of products. So by definition products are only traded by suppliers and in between suppliers. Supply chain partners who trade products in terms of a stock of services for a certain period of time to end-users (*services market*) are *service providers*. It is in the economic interest of suppliers to guarantee that products can be kept and traded within the loops. For the same reason complex products (components, especially those compiled out of products with different life spans) are designed for disassembly, so they can be dismantled and traded in parts within the *supply chain market*. A product that has reached the end of its economic lifecycle, which cannot be traded within the supply chain market nor on the service market is returned to earth via the biological loops. Within a Radical CE every transaction between the supply chain and service market is in the form of '*operational lease'* or '*pay-per-use*' (the more impure forms imply: financial lease, buyback and take-back).

Radical CE, some reflections

Radical CE has consequences for the definition of a sustainable product. Within a Radical CE a product is sustainable if the product as a whole or in its constituent parts remains to be traded on the service market, or while cycling in the technical loop on the supply chain market or alternatively is given back to the natural world trading it through the biological loops. As within Radical CE clean energy is endlessly available, so nor maintenance, nor designing for durability makes a product more sustainable. Also the so-called 'functional degradation' at the end of a service life span has in principle no influence on the sustainability of a product, unless degradation implies shortening cycling within the technical loop. Finally, within Radical CE products require no assurance in terms of being kept in the loops. It is axiomatically assumed that the scarcity of resources and the resulting inflation ensures an economic incentive for supply chain partners to trade the (assembled) products sustainably at the service or supply chain market. So, designing a truly Radical CE product/component requires a systemic approach and will need new forms of cooperation among multiple actors operating in different parts of the supply chain, between producer and end-user.

Radical CE implies a decomposition of complex products, primarily in parts compiling a marketable stock of services of which the constituent products have also validity within the business models of the supply chain partners owning these parts. For such a product in form of a complex component not only the strategic assembly of the products is of great importance but also the junctions and fittings between the constituent parts. In Radical CE every junction needs to be modelled with its' own life

span, maybe even its' own supply chain partner(s) and requires an investment decision, which cannot always be taken by a single responsible supply chain partner. As a complex product ought to be designed, engineered and constructed as a stock of services, composed in terms of materials, products and components from a CE perspective, new types of value models have to be developed to steer belonging the processes of decision making.

A building as manifest on a Radical CE services market can be characterised as a complex component existing out of subcomponents/products with different functional life spans in relation to the economic lifespan of the whole. The subcomponents might be owned by different supply chain partners and are traded, whether or not separately, as services by service providers. So design for disassembly needs to be incorporated in the business models. If constituent products within the complex component have shorter functional life spans as the whole, then these parts must be removable, replaceable and tradable. Furthermore, the above mentioned replacements asks for new forms of regulations between service providers and supply chain partners, as well regulations between service providers and end-users. The more products (subcomponents) that are owned by different supply chain partners, especially in case of different life spans, the more complex these regulations will be. Removal of products with a shorter life span within a complex component preferably has to be done without harming the connected parts. The mitigation of risks concerning the continuity of the services might be performed by the service provider on behalf of the supply chain partners acting together in a kind of cooperative company.

A service provider/lessor holds a 'pay-per-use' or 'operational lease' contract with the end-users as a lessee. Under current regulations, this implies that the service provider owns the products in the form of company assets. In case of capital-intensive assets, this has wide implications for the business model and the companies funding structure (funding, liquidity, solvability). In terms of balance sheet management, risk mitigation, asset management, depreciation method, the income statement and taxation, the various measures of CE have far-reaching consequences that cannot be adequately addressed within the current market conditions and regulations. The implementation of Radical CE therefore requires adjustment in enterprise strategy and business finance models, funding mechanisms, governance structures, regulations and government policy. This relates to the level of supra-national-building-regulations-within the construction industry as whole as well as individual building projects. For instance, at he moment it seems rather impossible to get a 'product inflation swap' (compare with interest rate swaps, day trading and options and futures on the commodity futures market) on products with a duration of lets say 20 years.

In a Radical CE market it makes sense to disassemble the custom made one off buildings, which after their first use period might be assumed to have limited tradability as a whole, after the first contract period, where the disassembled products are then traded on the supply chain or service market. This is also because within 'Radical CE', consumers of CE goods are not the (legal) owners but only own a user right. The question remains whether consumers can trade user rights in the consumer market because of the lack in legal ownership of the goods. User rights are not without legal clauses, but are contractually agreed between the suppliers (rights-giving) and consumer (rights-getting). When these user rights are traded by consumers, a supplier should be able to claim its rights when needed in a chain of consumers over time. This doesn't seem really realistic at the moment. So the real estate market as existing today, for larger parts will disappear while implementing Radical CE.

In ‘Radical CE’ the identity of materials/parts, products and components should be registered in the form of a passport. Identity represents the embedded value and provides a tool for the service provider to trace the products.

Radical CE implies the assessment of a product being CE can only be measured in Kg of materials used under in essence the condition -100% non virgin- materials at the start of a cycle, equals the amount of materials marketable on the service or suppliers market, out at the end.

DUTCH CE CASES EVALUATED

In this paragraph the Radical CE construct is applied to a few cases on building and product level within the Dutch construction industry. To do so the research relies on theoretical sampling (i.e., cases are chosen for theoretical, not statistical, reasons, Glaser & Strauss, 1967).

The ‘Town-Hall of Brummen’ (2014), which is often mentioned as one of the first and most famous CE project in the Netherlands, is a project designed for disassembly, implies a bio-degradable construction and several C2C products. However, this project has no proof for incentives for the suppliers for even one loop after its first use-cycle (for instance in the form of a buy-back guarantee) hence it’s not really circular according to the Radical CE concept.

The renovation of the headquarters of ‘Tennet’ (2014) is an example that comes closer to reach Radical CE. In this project a take-back guarantee is incorporated, within the procurement process, for all its furniture and infill. This relates to one single loop after its first use-cycle. This however is not primarily realised through financial incentives within the business model of the supply chain partners but forced through procurement pressures in the form of take-back guarantees. It’s still not evident that the taking back of components by the suppliers is done primarily from out their circular business model. The case is much presented within the ‘Dutch CE circuit’ but till so far not described in the literature. According to the presentations on this case the resulting effect of the special procurement method used (the so called PRP method of the firm Rendemint) it was calculated that only 7% (in kg) of all materials were really circular (in PRP terms, could be re-used without waste and with equal functionality).

Within the Netherlands two product related cases are most often provided as famous CE examples: the pay per lumen concept of Philips and the carpet tiles as produced by Interface and Desso.

The pay per lumen –LED- light concept (2013) is developed by ‘Philips’ for the office of RAU Architects in corporation with ‘TurnToo’ (TurnToo, 2015). The Pay per lumen idea seems to have an ideal CE fit but its unlikely, and nowhere documented, Philips having changed neither the product nor its business model according to CE principles because of this project. Thus as the incentive for even one loop after its first use-cycle is missing, the product is not yet really circular.

Interface and later on Desso have entered the market with carpet tiles, which can be –operationally- leased, or bought. Both firms also have incorporated the take back of already existing carpet tiles in their business model for recycling them into new ones. So instead of paying for the discharge, one could say owners get paid for their waste of carpeting (Desso, 2015). There are no formal guarantees the tiles will be re-used to

manufacture new ones which sometimes is criticised by those wanting to regulate CE, but form a Radical CE perspective these manufacturers fulfil all necessary CE demands as recycling old tiles into new ones is incorporated into their business model.

The Gilde opleidingen project concerns an educational building, which had to be renovated. The project is done with professional participation of this papers' authors, trying to implement Radical CE principles. Every supply chain partners took back the demolished materials/parts and products, resulting from the renovation, this related to their own business model, for reuse and recycling. The firms selected were asked in their proposal to translate their –assumed- financial benefits in form of the embedded value of these materials and products, in the form of a discount on the new products provided by the same supply chain partner. Finally, a take- and/or buy-back guarantee, captured in a resource passport, is incorporated for all the new products that supply chain partners have provided. The resource passport has the form of a digital Building Information Model (BIM). Hence this project is realised through financial incentives within the business model of the supply chain partners, which they have to prove in terms of discounts for the client. The firms were not ask to prove their business model was circular, they were forced to act as such by making profits explicit in forms of discounts for the client. As the service concept is not implemented, also this case isn't fully compliant to the rules of Radical CE.

CONCLUSION AND REFLECTIONS

The aim of this paper was to re-define CE into 'Radical CE', attempting to constitute a CE theory and terminology, appropriate for the construction industry and addressing the core of the CE concept in terms of a resulting sustainable society, behaving as such because of economic incentives.

As described 'Radical CE' in its pure form will have consequences for the definition of sustainability. It's not the long life span of a product whether or not realised by making it adaptable, which make it sustainable but its potential to be endlessly kept within the technical cycle. In other words buildings, more especially custom made one off buildings, don't need to be designed for 'eternity', but for demolishing after the –first- functional live span has ended.

Buildings need to be designed and constructed as a stock of services, composed in terms of products and more complex components from a CE perspective. This implies the constituent parts of a building must have validated economic value in terms of tradability on the supply chain market or services market. So, design for disassembly or demolition needs to be incorporated in the business model of the suppliers involved.

If constituent products within a complex component like a building have shorter functional life spans as the whole then these parts must be removable and replaceable. A building has to been seen as a composition/system of components and connections between them which are economically meaningful within the business models of suppliers who owns them and keep them circulating. While doing so Radical CE asks for new forms of regulations between service providers and supply chain partners, as well as between service providers and end-users and requires adjustment in enterprise strategy and business finance models, funding mechanisms, governance structures, regulations and government policy.

In a ‘Radical CE’ Market the question remains this especially for real estate, whether or not consumers can trade user rights in the consumer market because of the lack in legal ownership of the goods. When trading these user rights by consumers a supplier should be able to track (resource passport) and claim its rights when needed in a chain of consumers over time. This doesn’t seem really realistic at the moment. So the real estate market as existing today, for larger parts will disappear while implementing Radical CE.

Axiomatic for CE is the availability of –endlessly- available clean energy, and rising prices, due to scarcity, of materials. Radical CE is developed as a concept for pushing CE to the limits in terms of endlessly riding the ‘loops’ based on a rather neo-liberal interpretation. CE then is an economic system, which logically (free market) results in a sustainable industrial production. If one interprets CE as an economic system, which has sustainability as a goal, then a more –centrally- planned economy is needed. In both cases however to a large extend new regulations at all levels seem unavoidable, supply chains needs to reorganized, and new business models needs to be developed. Essential for the construction industry is the remodelling of a building in terms of an ensemble of components with each on their own have endless economic value within the technical loop or and can be traded separately to clients and end users providing housing services.

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