# Reconfiguring which systems? An interdisciplinary reflection on units of analysis in the Circular Economy transition

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## Abstract

The circular economy (CE) is gaining attention as a new concept for sustainable development. The interpretively flexible concept has evoked critical discussions of its practical and theoretical purchase, however. Following calls for CE operationalization, this contribution provides a theoretical-methodological reflection on the relevant system understandings and units of analysis. Taking sustainability transitions research as a general conceptual background, an operational 'CE configurations framework' is developed through interdisciplinary knowledge integration between governance, sustainability evaluation and sustainable urban (re-)design perspectives. The framework supports empirical CE research that is focused yet sensitive to the wider transitions dynamics within which CE practices are embedded.

# 1 Introduction: Operationalisation challenges in the Circular Economy

The circular economy (CE) is gaining attention as a new concept for sustainable development. Other than constituting a particular sustainability solution, it rather denotes a paradigm shift away from the prevailing make-take-dispose approach to consumption and production (Merli et al. 2018). The CE has developed into a widely endorsed socio-technical imaginary (Jasanoff & Kim 2009) that guides a wide range of innovations. Its attractiveness arguably resides in its constitution as an ecological modernization discourse (Cf. Hajer 1995): As the 'closing of the consumption and production loops' revolves around efficiency improvements in both ecological and economic terms, the concept highlights the scope for sustainability advances within the prevailing institutional constellations of market democracy.

Unsurprisingly, the interpretively flexible concept has evoked critical discussions of its practical and theoretical purchase. First, its positive-sum format has met with the usual critical inquiries into the reconciliation of social, environmental and economic sustainability dimensions (Korhonen et al. 2018: 40). Generally implying a limited, environment and business-focused understanding of sustainable development, Geissdoerfer et al. (2017) argue the CE to be only a part of more comprehensive sustainability strategies – as such requiring specification of the precise normative finalities, impacts and trade-offs involved. Second, there are the concerns over its apparent 'technological fix' character. CE scholarship is as yet not very attentive to social and institutional dimensions (Moreau et al. 2017), and the abundant studies on Chinese CE policies are difficult to transfer to other less centralized governance contexts. Third and perhaps most fundamentally, there are widespread calls for operationalization. Blomsma & Brennan (2017:2) point out how the CE 'umbrella concept' has usefully bundled previously unrelated notions in waste management and industrial ecology into a discursive space. Recently it has entered the 'validity challenge phase', however, in which its lasting relevance will need to be established. Amidst a confusing multitude of CE models, approaches, methods and metrics, urgent questions arise on the relevant 'CE configurations' (ibidem: 8) at issue. It is striking in this regard how CE is often characterized as a systems approach (Ghisellini et al. 2016: 14; Geissdoerfer et al. 2017: 766), referring interchangeably however to different entities such as supply chains, business models and innovation systems: Which systems are to be reconfigured?

Rising to the challenge of CE operationalization, this contribution provides a theoretical-methodological reflection on the system understandings and units of analysis through which to conduct focused and meaningful empirical studies: *How to conceptualize the 'systems' to be reconfigured in the CE transition? How to methodologically demarcate and develop appropriate 'CE configuration' cases?*

Our exploration of these questions takes sustainability transitions research (Grin et al. 2010) as a general conceptual background. As a systems-based, socio-technical approach to sustainability issues, it is particularly suitable to guide the exploration of the CE operationalization challenges. It raises attention to the multiple kinds of innovation involved (Smith et al. 2010), the path-dependent social structures with which CE innovations need to be fitted in (Grin et al. 2010), and the co-evolution dynamics through which CE innovations are reinforced are dampened (Geels & Schot 2007). The transitions perspective does not provide a ready-made model, however. Beyond the frequent casual references to CE

'transitions' (e.g Ghisellini et al. 2016; de Jesus & Mendonça 2018), it remains to be seen whether these can be grasped along the transitions-analytical templates of energy, mobility and agriculture 'regime shifts'. We therefore build on critical transitions scholarship proposing alternative system understandings such as the 'arenas of development' (Jørgensen 2012), the 'socio-energetic node' (Debizet et al. 2016), 'whole system reconfiguration' (the conference theme), 'deep transitions' (Schot & Kanger 2018), 'diverse transformations' (Stirling 2011) or the dispersed system changes theorized by Hodson et al. (2017). As pointed out by Geels (2010), these systems-theoretical explorations are significantly supported by the availability of the MLP-model as an ontological platform for interdisciplinary knowledge integration. Taking the transitions perspective similarly as a platform for critical systems thinking (Ulrich 2003), we explore the 'CE configurations' through a confrontation of governance, sustainability evaluation and sustainable urban (re-)design perspectives. Bringing forward contrasting conceptualizations, dimensions of innovation, units of analysis and associated observables, these perspectives help to translate the general transitions understanding into a 'CE configurations' framework that supports focused and meaningful empirical research.

Our exploration proceeds as follows. First we discuss CE operationalization challenges and the search for 'CE configurations' as units of analysis **(section 2)**, followed by a methodological argument for a critical systems thinking approach **(section 3)**. Accordingly, the interdisciplinary elaboration 'CE configurations' takes place in two steps. First developing a general transitions-oriented conceptualization **(section 4)**, further specification into a CE configurations framework is achieved through the confrontation of governance, sustainability evaluation and sustainable urban (re-)design perspectives **(section 5)**. The concluding section summarizes findings and implications for the investigation of CE transitions **(section 6)**.

## 2 CE operationalization challenges: which systems?

Characterizing the CE as an 'umbrella concept', Blomsma & Brennan (2017:3) acknowledge that the Circular Economy (CE) is a vague but not an empty category. The particularly rich and layered concept has roots in different research areas (e.g. industrial ecology, ecological economics, sustainability assessment, waste and resource management), it has been promoted by private sector actors as an alternative business philosophy, and through the endorsement of various governmental actors it has become a policy discourse as well. The 'CE' is not just describing certain states of affairs, as it exemplifies the performative effects of politically powerful 'policy discourses' (Hajer 1995). Moreover, its co-production by both political and science actors allow the CE to operate as a 'socio-technical imaginary' (Jasanoff & Kim 2009), providing a horizon for innovation and societal transformation. Considering its shaping through such heterogeneous 'triple helix' kinds of actor networks, it becomes obvious how the meaning and denotations of the CE concept evolve over time. Blomsma & Brennan (2017) diagnose in this regard how the CE 'umbrella' at first facilitated the cognitive convergence needed for collective action. Later on, the broad 'discursive space' proved to leave considerable room however for contention and misunderstanding. Considering how this confusion has come to jeopardize the broad endorsement, they identify that the concept has

now entered the 'validity challenge' phase. In this phase a CE understanding will have to be consolidated that ensures its lasting relevance, countering the mounting scepticism about its interpretive flexibility.

The authors focus their consolidation effort on what is arguably a key strength of the CE concept, namely its constitution as a timely mode of *systems thinking*. In order to realize this potential and work towards comparative, solidified CE insight, a certain balance has to be struck between the general and the concrete. They therefore recommend CE research to proceed with 'CE configurations' as units of analysis. This concept underlines on the one hand how the circularity cannot be understood in terms of singular and isolated practices, whilst on the other hand denoting concrete, situated practices:

> *"The CE concept implies, after all, a shift away from implementing and assessing singular strategies, to the assessment of different circular configurations: situations where two or more different RLESs [resource life-extending strategies] work together in sequence or in parallel.(….) Effectively, configurations need to be studied as a unit-of-analysis in their own right. From this, one could identify what makes configurations effective, for example, and how, recycling and reuse could generate synergies."* (Blomsma & Brennan 2017: 8).

This proposal clearly reflects a wider search within CE scholarship systemic understanding. The various recent review articles are particularly revealing of the challenges ahead. Reminding how the CE is rooted in systems thinking, Ghisellini et al. (2016) bring forward interesting thoughts about its significance for paradigms of economic growth and de-growth. Casting CE development in terms of 'transitions', they highlight the promise of the concept to guide broad processes of system innovation. Still, their stock-taking demonstrates how CE scholarship is as yet quite fragmented along micro, meso and macro perspectives, and also the authors themselves refer to a diverse range of system 'transitions'. Particularly telling in this regard is the 'Lost in transition' account of de Jesus & Mendonça (2018): Seeking to develop 'a thorough understanding of the factors that foster and hinder the transition to a CE' (ibidem:75), the very notion of this 'CE transition' is left highly unclear: Would it be part of a transition, itself a transition, or a transition comprising other transitions? Is eco-innovation a means to this transition, or a near-synonym that similarly indicates the argued need for 'transformative', 'systemic' innovation? And what changes in practices and paradigms does the 'CE transition' refer to?

> *"The CE has emerged as a key approach in the transition to a more sustainable economic paradigm"* (ibidem:75)

> *"Eco-innovation (EI) is considered to be an essential pathway for overcoming barriers to a CE transition"* (ibidem: 85).

> *"The focus on the promotion of* systemic *EI (Eco-innovation) is also of paramount importance. The challenge is, nonetheless, to direct "innovation systems" towards CE-inducing productive and social practices."* (ibidem: 85)

The above quotes display the persistent challenge of moving from general concepts towards operational systems understandings. Throughout the various considerations of sustainability impacts, paradigm shifts and system transitions, a basic but complicated question keeps returning: *Which systems?* A particularly instructive contribution to this debate has been Geissdoerfer et al. (2017), considering what is *not* part of CE systems. Calling for thorough

analysis of CE sustainability performance in supply chains, business models and innovation systems as different instantiations of CE 'regenerative systems', the authors urge for a line of systems thinking that better articulates the specificities and limitations of CE practices. This raises attention to the fact that CE development is likely to be only one of several system shifts through which to ensure sustainable development, and to the widely acknowledged but not always articulated circumstance that this system shift promotes a quite selective, eco-efficiency oriented understanding of sustainability.

## 3 Methodology: Critical Systems Thinking and transitions research

The challenge of CE operationalization is widely taken up through various elaborations in terms of systems and their associated system transitions. This quest for CE systems understanding is somewhat paradoxical: Whilst the confusing proliferation of system models is widely lamented, new proposals keep coming. Whilst the CE is widely acknowledged to be applicable at various micro, meso and macro levels, it keeps being referred to in terms of singularizing notions ('the CE system', 'the CE transition'). And whilst the CE is widely endorsed as a systemic view on sustainable development, the concrete interactions between system components and system-environment relations often remain under-determined.

As members of an interdepartmental research hub on the CE that is in an early stage of development, we have faced similar challenges of developing a common understanding. Seeking to exploit the complementary insights of urban design, sustainability assessment and governance perspectives, it became clear soon enough how our general convergence on 'sustainable CE', 'system change' and 'CE transitions' was accompanied by different takes on the topic that often remained largely implicit. Seeking to develop CE case studies, it thus became apparent how we conceived the CE in terms of spatially situated urban regeneration processes, social innovation initiatives in organizational fields, or widely extending chains of production and consumption. In light of these ambitions towards interdisciplinary synergy and commitments towards thorough, sustainability-oriented CE development, the 'which systems' question became particularly pressing.

Seeking to lay a methodological foundation for interdisciplinary research, we follow the proposal by Blomsma & Brennan (2017) to carve out 'CE configurations' as relevant units of analysis – whilst realizing that the further elaboration of this general concept is as important as it is difficult. Acknowledging the CE as a polyvalent concept with broad societal significance, this is not only a matter of introducing scientific rigour (Cf. Korhonen et al. 2018). Rather than assuming the availability of single-best answers and the privileging certain scientific perspectives to decide on a appropriate systems understanding, our methodological reflection on units of analysis rather amounts to the stabilization of a societal discourse – as such forming part of the struggles towards establishing hegemony around this socio-technical imaginary (Cf. Wullweber 2015 for similar dynamics around 'nanotechnology'). Our methodological reflections are grounded in Critical Systems Thinking (Ulrich 2003). The basic characteristic of this reflexive mode of systems thinking is that system understandings are cognitive devices to order complex, fluid realities (Cf. Law 1992; Pel et al. 2017 on this 'punctuation'), highlighting some and backgrounding other

aspects. To speak of a CE system is to single out a set of system components and relations (e.g. an eco-industrial park, or a country committed to a national CE policy plan) from a certain system environment (an industrial region, or an industrial paradigm), identifying particular focal actors and processes within otherwise boundless actor networks. These system demarcations or boundary judgements are often held as implicit assumptions. By contrast, a CST approach underlines that system understandings are seldom obvious (Cf. Vayda 1983 on 'progressive contextualization'), often not entirely articulated, and generally containing important normative assumptions about problems, solutions, insiders and outsiders. It suggests to elaborate the 'CE configurations' notion through a dialogical mode of systems thinking – probing, questioning and unfolding a multitude of system understandings, and considering how they may complement each other. Our interdisciplinary elaboration of 'CE configurations' has taken place in two steps. First developing a general conceptualization in terms of sustainability transitions, we have triangulated our governance, sustainability evaluation and sustainable urban (re-)design perspectives for the necessary next-level operationalization.

Regarding the first step, the CST approach has clarified why sustainability transitions research (Grin et al. 2010; Loorbach et al. 2017) provides indeed an appropriate framework for CE operationalization (Cf. Ghisesellini et al. 2016; de Jesus & Mendonça 2018) – even if also requires further operationalization. As will be exposed in section 4, transitions research brings forward several insights and associated system understandings through which to meet the sketched CE operationalization challenges (Cf. section 2). In line with the general idea of Blomsma & Brennan (2017), it conceptualizes 'CE configurations' for example as socio-technical systems that involve multiple kinds of innovation. Regarding the general but not very articulate casting of CE development in terms of radical systemic change, it situates local CE practices within broader structures of nested systems and path-dependent 'regimes'. Moreover, the framing in terms of transitions introduces the explicit normative rationale of sustainability. This is essential, considering the confusions about system purposes and performances that Geissdoerfer et al. (2017) and Korhonen et al. (2018) rightly identify as persistent challenges to CE operationalization.

Relentlessly asking for specification of system understandings, the CST approach has also underlined however how transitions research does not provide a ready-made systems model that is of obvious relevance to CE operationalization. To begin with, the CST approach calls attention to the confusing multitude of 'CE transition' accounts, and the particular ways in which they share in the general vagueness in CE scholarship about the 'systems' at issue. More importantly, the approach helps to gather and organize the considerable amount of systems-theoretical reflections, conceptual proposals and operationalization efforts through which transitions scholarship has critically explored the 'systems' to be transitioned. This transitions-theoretical capacity for CST speaks from interrogations of which and whose systems are to be transformed by whom (Smith & Stirling 2010), empirical analyses of political struggles around broader and narrower system understandings (Pel & Boons 2010), and arguments for a more profound engagement with the directionality (Stirling 2011) and normative dimensions of transitions (Schlaile et al. 2017). Likewise, there has been ongoing debate about the relevant units of analysis, as speaks from the accounts of 'arenas of development' (Jørgensen 2012), the 'socio-energetic node' (Debizet et al. 2016), 'whole

system reconfiguration' (the conference theme), 'deep transitions' (Schot & Kanger 2018), or the dispersed and multiple system changes theorized by Hodson et al. (2017).

The sketched CST applications indicate how sustainability transitions research provides not only a general 'backdrop', but also serves as a platform for interdisciplinary explorations. After all, transitions research has developed through interdisciplinary knowledge integration (Grin et al. 2010), and its central Multi-Level Perspective (MLP) heuristic provides an ontological platform from which to undertake informed and coherent paradigmatic interplay (Geels 2010). Geels recommends this interdisciplinary interplay as a way to zoom in onto particular aspects of empirical phenomena. With regard to the elaboration of 'CE configurations', our urban design, sustainability assessment and governance perspectives provide essential next-level operationalization of the transitions-based 'CE configurations' conceptualization.

## 4 CE configurations: a sustainability transitions conceptualization

Seeking to strengthen the CE concept as a mode of systems thinking, Blomsma & Brennan (2017) propose the investigation of 'CE configurations'. As a first step in our Critical Systems Thinking approach to this methodological issue, we invoke sustainability transitions research to develop a relevant general conceptualization, i.e. a conceptualization informing focused research that accounts for key aspects of CE dynamics. In the following we identify five transitions-theoretical insights, each clarifying key challenges of CE operationalization. These pertain to system purposes **(section 3.1)**, aggregation level **(section 3.2)**, system components **(section 3.3)**, and system interactions **(section 3.4)**. We conclude this conceptual elaboration with a 'CE configuration' definition **(section 3.5)**.

### *4.1 System purpose: Sustainability and the directionality of transitions*

The CE bears the typical ecological modernization promise of a triple win on the social, economic and environmental dimensions of sustainability. A significant part of the CE 'validity challenge' consists in the evaluative weakness of this general 'positive sum' discourse. Without explicit normative yardsticks and clarified system purposes, it remains fundamentally unclear what kinds of system reconfigurations the CE can be taken to refer to, and what system-innovative achievements are being made. Seeking to bring scientific rigour to the idealistic and vague discourse on 'sustainable' CE, Korhonen et al. (2018) invoke sustainability science to establish the environmental, economic and social dimensions of sustainable development as the appropriate evaluative framework. Clarifying system purposes through this 'triple bottom line', it becomes easier in turn to address a host of evaluative challenges that haunt CE development: Geissdoerfer et al. (2017:765) point out that the sustainability assessments of CE configurations tend to be limited to environmental impacts, and that the various trade-offs are poorly articulated. A related challenge consists in accounting for the various rebound and problem shifting effects involved with bounded CE practices (Korhonen et al. 2018: 43). Finally, there is a widespread awareness in CE

discourse of the various (thermodynamic; social-economic) limitations towards a fully circular economy – but how to provide further articulation of the critical awareness that the transition amounts to moves towards a *more circula*r economy (de Jesus & Mendonça 2018: 76)?

Transitions research provides useful foothold regarding this normative dimension of CE system understandings. Increasingly often described as *sustainability* transitions research, it casts CE development within the broader mission of addressing persistent, systemically rooted sustainability problems (Rotmans 2006; Grin et al. 2010). Accordingly, it warns against shallow, incremental sustainability measures, the short-term gains of which tend to be offset by their reproduction of the prevailing modus operandi, cultures and infrastructures of unsustainable socio-technical 'regimes'. The transitions perspective thus brings an emphatic commitment to structural sustainability, and a particular sensitivity towards the CE operationalization challenges of diluted sustainability, rebounds and problem-shifting. The through its theorization of confrontational processes between radical 'niches' and dominant 'regimes', transitions research is in principle well-equipped to grasp the politics of the CE – where its interpretive flexibility creates a grey zone of multiple more or less instrumentalized and sustainability-oriented CE 'translations' (Pel 2016).

Still, it needs to be said that the transitions framework provides only a general account of the normative dimension of CE configurations. The directionality of transitions (Stirling 2011), i.e. the multiple directions in which systems may co-evolve, remains largely implicit in transitions accounts. Likewise, there have been calls for transitions research that is more attentive to the often subtle nuances between the sustainability understandings at issue in concrete transition contexts (Pel & Boons 2010; Hodson et al. 2017). Better articulation is arguably needed of whose 'system' is to be transitioned by whom, and why (Smith & Stirling 2010; Schlaile 2017). Moreover, the fundamental critique by Svensson & Nikoleris (2018) is highly relevant for the CE: The transitions-theoretical focus on shifts in societal rules is abstracting from the material impacts involved. *CE configurations should therefore be conceived as practices in which multiple sustainability understandings are confronting, and in which multiple sustainability impacts occur.*

### *4.2 Aggregation level: Transversal regime changes, embedded configurations*

Any system understanding presupposes demarcation, specifying the size and scale of the systems at issue. A second key challenge to CE operationalization resides in the global-scale changes it generally assumes (Geissdoerfer et al. 2017: 762). The associated principles of steady state economy, development within planetary boundaries and balanced metabolism inform many ideas about the mitigation of production and consumption processes, yet as general system understandings they hardly inform focused analysis. In fact, CE scholarship seems to proceed through limited reflection on aggregation levels. Merli et al. (2018) chart for example a large bandwidth of micro-level studies on alternative consumption and product design, macro-level shifts in societal structure and administration, and meso-level processes of inter-firm industrial symbiosis. Also Ghisellini et al. (2016) classify CE analyses at various aggregation levels, identifying a gap between the bird's eye view analyses of large-scale

metabolism and the contextualized accounts of CE governance and experimentation processes. They warn in this regard that the extensively documented Chinese examples tend to convey assumptions of large-scale coordinated action, yet these system models do not apply in situations of more distributed governance structures. Next to these concerns about insufficiently context-sensitive system understandings, there also concerns however about the inverse risk of missing the bigger picture. Korhonen et al. (2018) stress the challenge to account for the shifting-of-problems that any spatially bounded CE practice is vulnerable to.

Through its roots in complex systems theory (Grin et al. 2010), transitions research situates the bounded CE configurations of Blomsma & Brennan (2017) within a bigger picture of nested systems. This deepens the aggregation level issue, moving beyond the casual undifferentiated references to *the* 'CE transition' (Cf. section 2). Taking transitions complexity and the associated nested-systems ontology seriously (Vasileiadou & Safarzynska 2010), CE configurations need to be studied as *embedded* units of analysis. Regarding the further choices of micro, meso and macro levels of analysis, there is ongoing debate within transitions research about the relative merits of zooming in or out. Various concepts have been brought forward that inform 'progressive contextualization' (Vayda 1983), i.e. an approach in which the level of analysis is consciously shifted to explore the relevant system boundaries.

A first marker for this is provided by the abundant calls for modes of analyses that are more fine-grained than the macroscopic accounts of (historical, or prospective) 'regime shifts'. In line with the geographical turn in transitions research, Hodson et al. (2017) argue for a focus on the multiplicity of experimentation processes in specific urban contexts, to increase attentiveness to material-geographical-governance contexts. CE configurations could similarly be studied as 'arenas of development' (Jørgensen 2012), to increase attentiveness to their situated shaping through mixes of radical 'niche' innovation and 'endogenous regime renewal'. This attentiveness to bounded, embedded processes of system innovation in the making meets the rather confined, micro-level 'CE configurations' that Blomsma & Brennan (2017) seemed to have in mind.

A second marker pertains to the need for zooming out from situated practices and attentiveness to the bigger picture – without which the analysis of CE configurations would tell little about CE *transitions* (Schot & Geels 2008). The study of CE configurations should shed light on the 'linear economy regime' that CE configurations are impinging on and shaped by, and account for 'landscape' level developments (such as pressures towards environmental efficiency, geopolitical changes, the ICT revolution, searches for sustained economic growth, and shifts in culture and governance). An important difficulty here is that no clear 'linear economy' or other regime can be distinguished, and that the CE seems to elude the conventional sector-oriented transitions analyses. Rather amounting to a diverse set of dispersed system changes that cut through several sectors (energy, agricultural production, construction), it makes sense to approach it as a phenomenon of transversal transition. This transversal zooming out can be appreciated as a probing of the 'meta-regime' shifts as theorized by (Schot & Kanger 2018), also in line with the conference theme of 'whole system reconfiguration'.

To conclude, the CE should be studied as *transversa*l, pervasive *regime change*, consisting of a *multiplicity* of *bounded*, *embedded* CE configurations.

### *4.3 System components: social-material coupling.*

Any systems understanding presupposes an idea of system components. Within the systems discourses of particular disciplines these are often held to be obvious, yet for the multi-disciplinary field of CE scholarship this complicates the operationalization challenges. The obvious system components for the CE are the various material and energetic inputs and outputs that form the 'metabolism' targeted for intervention and transition. This speaks from the CE discourse of loops, cycles, flows and metabolism, but also from the many CE system visualizations that have been drawn (Cf. Blomsma & Brennan 2017:3). CE scholarship remains rather inattentive to the institutional and cultural dimensions, as the reviews of Ghisellini et al. (2016) and Merli (2018) bring out. Moreau et al. (2017: 4) explain how this may reflect the ecological metaphors that surround the concept, which make for naturalizing system understandings devoid of power and politics. The authors underline in this regard that CE development inherently involves institutional changes: what counts as 'recoverable waste' is crucially governed by formal institutions and social norms. Korhonen et al. (2018) underline in this regard how CE development presupposes new modes of consumption, inter-organisational collaboration as well as intra-organisational change. Arguing for greater attentiveness to the social, organisational and institutional innovations involved, the above contributes thus call for less materialistic CE system understandings.

Regarding this call for less reductionist system understandings, transitions research is of particular value. Combining insights from Science and Technology Studies and institutional theory, transitions research has developed the earlier notion of the 'technological paradigm' into a multi-dimensional understanding of socio-technical 'regimes'. From the perspective of innovation studies and sustainable innovation research, this has made for an essential broadening of perspective (Smith et al. 2010): Beyond the focus on sustainable technologies and eco-innovation (as also prevailing in CE scholarship), the transitions perspective underlines how sustainable development requires innovation along multiple dimensions. This highlights how the CE 'metabolism' is hard to understand (and to change) without accounting for system components like regulations, consumption cultures, business models and accounting systems. A paradigmatic example for the study of CE configurations is the analysis by Smith (2017) on the rise of the FABLABS and the Hackerspaces, showing how the various material CE contributions go hand in hand with less tangible but significant innovations in (self-) governance.

Focusing on 'regimes' as sets of dominant rules and further broadening towards the study of socio-*institutional* transitions (Loorbach et al. 2017), it needs to be considered however that transitions research may lead to the inverse of the sketched operationalization challenge, social reductionism. In line with the warning by Svensson & Nikoleris (2018) against such neglect of the materiality of systems, it will therefore be useful to ensure material-geographical concreteness. Relevant models for the CE configurations are in this regard the 'socio-energetic nodes' as coined by Debizet et al. (2016), and the urban 'reconfigurations' described by Hodson et al. (2017). This nuances the basic operationalization guideline that transitions research provides: *The CE configurations should be conceived as social-material systems, comprising multiple innovation dimensions.*

### *4.4 System interactions: Co-evolution and path dependence*

Directly related to the issue of system components is the question on how they interact and give rise to certain dynamics of system development. One of the strengths of the CE concept is that it provides a fertile general framework for this. The basic distinction of closing, narrowing and slowing down of production and consumption loops gives rise to various typologies and hierarchies of CE principles, which in turn inform the elaboration of specific models for specific aggregation levels and application sites. Still there is much left to specify about the system interactions, especially as long as the materialist system understandings (Cf. section 4.3) obscure the agency and institutional structures through which the various 'loops' could be reconfigured over time. A basic problem is that the CE describes a new system state (premised on circularity) that diverges from the prevailing (linear economy) state, as such distracting from the shift (or indeed the transition) between these states. This explains the striking idealism in CE discourse (Korhonen et al. 2018) regarding the scope for fitting in CE practices with the prevailing administrative routines and matured spatial-infrastructural systems of a linear economy. This assumption of highly malleable systems is problematic. Overlooking the path-dependent structures through which attempts towards CE tend to be resisted, neutralized or considered failures, it becomes equally difficult to conceive of the creation of new evolutionary paths – involving slowly evolving elements such as consumer habits and business routines, for example (De Jesus & Mendonça 2018: 83).

The obvious general relevance of transitions research resides in its process-oriented focus on system *transitions*. The basic starting point is that radical sustainability innovations run up against path dependent structures, that evolutionary 'niches' like many CE practices meet with the adverse selection environment of 'regimes', and that the crucial change of these selection environments occurs only through a multitude of co-evolving, mutually reinforcing innovations and changes (material adaptations, learning processes). Such 'regime' transitions are generally considered to be a matter of several decades (Grin et al. 2010). Regarding the study of CE configurations, involving relatively bounded innovation processes of transition in-the-making (Cf. section 4.2), it seems that more narrow time-scales are appropriate. Still, the transitions perspective does suggest to include a degree of both retrospective and prospective analysis, and to work with temporal demarcations that at least allow for some co-evolution dynamics to surface. Moreover, it underlines the relevance of working with CE configurations comprising a minimum multiplicity of CE innovations, as proposed by Blomsma & Brennan (2017) and underlined in the accounts of 'socio-energetic nodes' (Debizet et al. 2016) and 'multiple reconfigurations' by Hodson et al. (2017). Further attentiveness to co-evolutionary interactions can be achieved by a focus on the embeddedness of CE configurations and through research designs involving multiple intersecting CE configurations (Pel 2013).

*CE configurations should thus be conceived as path dependent, composite entities, developing through co-evolving system elements and co-evolutionary interactions with surrounding systems.*

### *4.5 Conclusion: A transitions perspective on 'CE configurations'*

In the search for CE operationalization and development of 'CE configurations' as units of analysis, several challenges arise. Invoking transitions research as a systems-based approach to sustainable development, a conceptual framework has been developed that specifies the 'CE configurations' through the following characteristics:

1) **Sustainability impacts and directionality.** CE configurations should be conceived as practices in which *multiple sustainability understandings* are confronting, and in which *multiple sustainability impacts* occur.
2) **Situatedness and transversal 'regime' change**. The CE should be studied as transversal, pervasive regime change, consisting of a multiplicity of bounded, embedded CE configurations.
3) **Social-material innovation.** The CE configurations should be conceived as social-material systems, comprising multiple innovation dimensions.
4) **Path dependence and co-evolution.** CE configurations should thus be conceived as path dependent, composite entities, developing through co-evolving system elements and co-evolutionary interactions with surrounding systems.

## 5 Operationalizing the 'CE configurations' framework: 3 perspectives

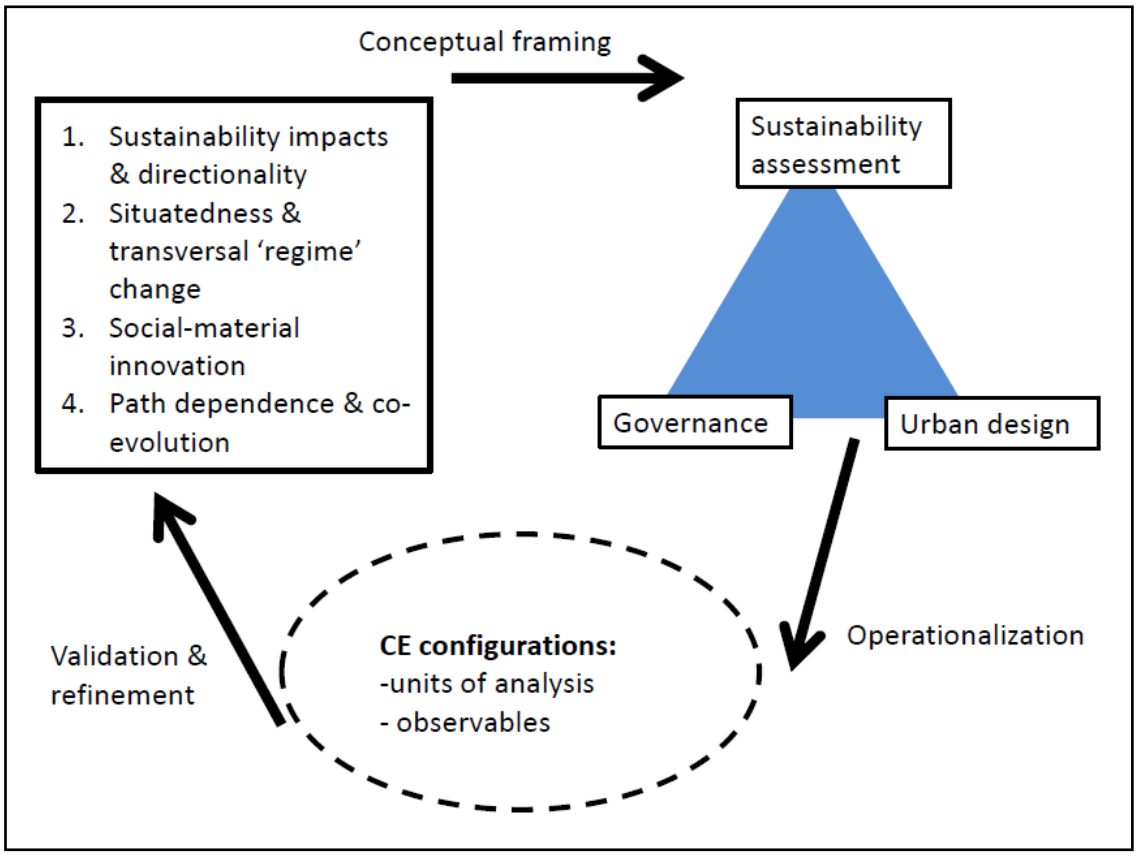
Sustainability transitions research provides an appropriate conceptualization of 'CE configurations', addressing several persistent challenges in CE operationalization. Transitions research provides only general guidelines for meeting those, however. Its rather macroscopic modes of analysis call for further operationalization in terms of units of analysis, empirical observables, and methods of empirical investigation. In this section we present preliminary insights on this second step towards operational 'CE configurations'. After a procedural account of our interdisciplinary knowledge integration **(section 5.1)**, we provide a first sketch of this next-level operationalization through urban design, governance and sustainability assessment perspectives **(section 5.2)**.

### *5.1 CE configurations: interdisciplinary elaboration of a general concept*

The transitions research conceptualization provides four instructive yet only general characteristics of CE configurations. The ensuing need for next-level operationalization does not detract from the relevance of transitions research. Instead, it rather reminds of the fact that transitions research does not provide a theory of everything, and even less so a methodological 'Swiss army knife'. In fact, the starting point for our reflections has been to pursue the synergy within the interdisciplinary triangle of urban design, governance and sustainability assessment perspectives – each of which are guided by particular drives and methodological capacities towards *concretization*. Following the critical systems thinking approach to CE operationalization, these contrasting modes of concrete analysis provide the

essential equipment for systems analysis, with the integrative transitions framework as a compass. This two-step operationalization is displayed in figure 1- also displaying how the interdisciplinary work will eventually feed back into the transitions-theoretical conceptualizations that guided it.

**Figure 1: Interdisciplinary approach to CE configurations**




The figure visualizes how the two-step operationalization of 'CE configurations' forms part of the reflexive method-theory loop that is typical for our critical systems thinking approach: Carefully developing and applying the developed systems understanding empirically, the empirical analysis of CE configurations will serve to validate, question and refine the theoretical assumptions that guided empirical research.

Even if beyond the scope of this methodological paper, the latter validation loop reminds of the systems reflection process that our interdisciplinary CE operationalization forms part of. Displaying the procedural context of our CE operationalization reflections, figure 1 also contains the following points:

- The four transitions-theoretical characteristics of CE configurations can be revised and extended; not only through empirical validation, but also through theoretical reflection. As an interdisciplinary and diversified research field, transitions research provides a multitude of concepts through which to develop CE system understandings.
- Particular elements of the four-fold conceptual framing will be more or less difficult to operationalize for the three constituents of the interdisciplinary triangle. In order to

enhance the consistency with the transitions framework (Cf. Geels 2010), the triangle may have to be built on particular strands of the three constituent disciplines.

- In place of or as additions to the interdisciplinary triangle worked with, many other disciplines can be drawn on to operationalize the transitions framework. Particularly worthwhile considering would of course be the various research strands currently leading in CE research (e.g. environmental economics, industrial ecology, waste and resource management).
- Bringing in particular research methods and understandings of relevant units of analysis and empirical observables, the three constituents of the interdisciplinary triangle may complement each other – but not necessarily so. The operationalization into focused research designs may involve the need for further narrowing down, and therewith for further conceptual specification of the CE 'systems' at issue.

### *5.2 Towards an operational 'CE configurations' framework: 3 perspectives*

Each in their own ways, urban design, sustainability assessment and governance perspectives bring forward particular ideas about what the relevant CE systems to be investigated comprise, and how to do this. Compared to the often rather abstract systems theorizing of transitions research, the three disciplinary perspectives share a drive towards concretization. They help to operationalize the four general characteristics of 'CE configurations' in terms of methodologies, units of analysis and empirical observables:

***Sustainable urban (re-)design.*** The most immediate relevance of this perspective resides in the fact that the 'CE transition' is in many ways an urban affair, involving the unbalanced production and consumption patterns of a still steadily urbanizing society. The focus on built environment and associated metabolic flows is of particular added value in light of the need for a balanced study of *social-material innovation*. In terms of *situatedness & transversal 'regime' change*, urban design brings along a sensitivity to 'sense of place' and local embedding, accompanied with a tradition of methodological reflection on scale, cross-level interactions and system intertwinement. The design tradition also brings along an experimental attitude that supports forms of transdisciplinary and prospective analysis. The very notion of sustainable *re*-design expresses sensitivity to the (materially) *path-dependent* contexts in which 'CE configurations' develop, which brings it in line with the long-term transitions perspective. It needs to be seen how the high-aggregation analyses of metabolic flows can be developed in sufficiently fine-grained and dynamic fashion however, in order to remain sensitive to co-evolutionary processes of system innovation.

***Governance.*** A governance perspective is particularly relevant as an antidote to the idealism that prevails in CE scholarship (Cf. Korhonen et al. 2018). Governance provides the obvious complement to materialist system understandings, raising attention to processes of social, institutional, and governance innovation as well as changes in cultures, discourses and social norms. In combination with the urban design perspective, it helps to substantiate social-material innovation. Focusing on diverse actor constellations with different understandings of CE sustainability, it strongly drives towards concretization of the directionality of the CE transition and the associated *sustainability impacts* – especially the economic and social

dimensions of sustainability. Regarding aggregation levels, the governance perspective is inclined to focus on the concrete and *situated* negotiations and political struggles of 'CE in the making', through analyses of arenas of development. This also helps to gain a clearer view of the *transversal change effects* of CE activities. Still, the governance does allow for zooming out to *'regime' change*, through concepts such as organizational fields and institutional logics.

***Sustainability assessment.*** Sustainability assessment has particularly strong capacities for the operationalization of the basic but notoriously challenging aspect of accounting for *sustainability impacts*. It helps to achieve considerable next-level operationalization beyond the general transitions conceptualization, also providing the tools for dealing with the various trade-offs, rebound effects and other complications of CE impact assessment. Through advances in social life cycle assessment, in can help integrate the respective sustainability assessments (and underlying normative yardsticks) brought forward through governance and urban design perspectives. In terms of aggregation level and *transversal regime change*, it may be useful to bring in lifecycle perspectives on production and consumption chains, as complementary units of analysis to those prevailing in transitions research. This seems compatible with the transitions focus on social-material innovation, with possibly additional insights on production chain innovation. Finally, this lifecycle perspective shares the longer-term temporality of the transitions framework – yet the sustainability assessment perspective is not particularly strongly oriented towards processes of co-evolution innovation and societal change.

Table 1 below summarizes the above rough sketches of next-level operationalization, distinguished along the three disciplinary perspectives and the four characteristics of the 'CE configurations'. A first picture arises of how these at first generally conceived 'systems' could be concretely studied: in terms of new governance arrangements and business models, changing performances of production and consumption chains and of mitigated flows in the urban metabolism. The integration of these different modes of CE system analysis arguably informs empirical investigations that help to grasp this rather elusive transition.

**Table 1: Interdisciplinary elaboration of 'CE configurations'**

| | **Governance** | **Urban design** | **Sust. Evaluation** |
|---|---|---|---|
| **Sustainability impacts & directionality** | Critical Policy Analysis<br>Politics of Transitions | Metabolic flow analysis | (Social) Life Cycle Analysis<br>Trade-offs & rebounds |
| **Situatedness & transversal 'regime' change** | Arenas of Development<br>Organizational fields<br>Institutional logics | Urban transformation<br>Neighbourhood transformation | Transversal Production and consumption chains |
| **Social-material innovation** | Social innovation<br>Institutional innovation<br>Cultural shifts | Urban metabolism; eco-efficient buildings | Production chain innovation |
| **Path dependence & co-evolution** | Institutional change<br>Social innovation | Re-design<br>Co-functionality | Lifecycle perspective |

## 6 Conclusion: Towards systematic CE transition research

The circular economy has become an influential 'socio-technical imaginary' for sustainable development, yet the polyvalent concept is entering what Blomsma & Brennan (2017) identified as the 'validity challenge' phase **(section 1)**. A promising way of meeting the calls for CE operationalization is to bolster it as a timely and powerful systems-theoretical concept. As yet, CE scholarship is surrounded with vague and under-determined references to 'systems' and 'system transitions' however – aggravating the 'validity challenge', more than resolving it **(section 2)**. In light of the challenges of grasping CE 'system change', this contribution has raised two basic theoretical-methodological questions: *How to theoretically understand the 'systems' to be reconfigured in the CE transition? How to methodologically demarcate and develop appropriate 'cases of CE'?*

We have approached these questions through critical systems thinking (CST). This is a reflexive mode of systems thinking that acknowledges how the discourse about 'CE systems' has been developed through academic, state as well as private sector parties, and how it has been shaped through different disciplinary perspectives. This constructivist mode of thinking acknowledges that there is no singular, obvious CE systems understanding – whilst emphasizing that implicit, inarticulate, imbalanced and incoherent system understandings need to be questioned and developed for the sake of reflexive practice (Ulrich 2003). Within this exploration of the CE 'systems' at issue, transitions research has played an important dual role. On the one hand, its commitment to sustainable development and its focus on the *processes towards* sustainable systems are helping to articulate and specify certain elements of CE discourse, casting it in a coherent framework. More importantly however, transitions research serves as a platform for critical systems thinking and interdisciplinary knowledge integration – the field provides fertile ground for explorations of alternative units of analysis (Jorgensen 2012; Debizet 2016; Hodson et al. 2017), critical interrogations of the systems at issue (Smith & Stirling 2010; Pel & Boons 2010), and efforts to deepen the debate about the normative yardsticks underlying the proposals for systems change (Stirling 2011; Schlaile et al. 2017) **(section 3)**.

Guided by the CST questioning of four basic system characteristics (system purpose, aggregation, components and interactions), transitions research has been invoked to conceptualize corresponding characteristics of the 'CE configurations' **(section 4)**. They should be investigated as:

1) practices in which *multiple sustainability understandings* are confronting, and in which *multiple sustainability impacts* occur.
2) multiple *bounded, embedded* units in processes of *transversal*, pervasive *regime change.*
3) *social-material* systems, comprising multiple innovation dimensions.
4) *path dependent*, composite entities, developing through *co-evolving system elements* and *co-evolutionary interactions with surrounding systems*.

This general conceptualization does require a next-level operationalization, however. Transitions research provides neither a theory-of-everything nor a methodological Swiss army knife. It does provide a framework that helps to integrate and create synthesis between

three perspectives that share a strong drive and capacity for concretization. Exploring how the general transitions-theoretical understanding can be operationalized through governance, urban design and sustainability assessment methodologies, the investigation of 'CE configurations' is clarified in several ways **(section 5)**. Apart from injecting considerable doses of spatial-material concreteness, rigorous normative assessment and critical social-political analysis into a naturalising (Moreau et al. 2017) and idealistic (Korhonen et al. 2018) CE systems discourse, the methodological exercise will eventually also feed back into transitions theory. Applying the framework in empirical analysis, the findings can serve to validate and revise various transitions-theoretical system assumptions. Can we meaningfully speak of 'the CE transition', for example, when such circular end state is principally unattainable, when implicit economic growth commitments create confusion about transition directionality, and when the empirical analysis yields indeed a picture of dispersed system changes across socio-technical 'regimes'?

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