INTRODUCING CIRCULAR INNOVATION IN THE CONSTRUCTION INDUSTRY: THE CASE OF THE CIRCULAR VIADUCT

Tom B J Coenen[1], Leentje Volker[2] and Klaasjan Visscher[3]

[1&2] *Department of Construction Management and Engineering, University of Twente, Drienerlolaan 5, Enschede, 7522 NB, The Netherlands*

[3] *Department of Science, Technology, and Policy Studies, University of Twente, Drienerlolaan 5, Enschede, 7522 NB, The Netherlands*

National and international governments have set ambitious targets to become circular in 2050. The aim is to reduce both the use of virgin resources and the generation of waste. To become circular, not only new technologies are needed in the resource-intensive infrastructure sector, but change is also needed in social and institutional aspects. This research focuses on one circular innovation trajectory in the construction industry: the Circular Viaduct. The purpose of this study is to gain insights into a past trajectory to study how future circular innovations can be fostered in the infrastructure sector from a client perspective. The innovation trajectory was studied using the mission-oriented innovation system (MIS) framework. The narrative of the innovation process was reconstructed in an in-depth case-study. By studying occurrences and sequences of events through MIS functions, underlying dynamics were identified. First, the trajectory shows that for such mission-oriented innovation the direction of the problem and solution together with knowledge development co-evolve rather than being separate stages. Second, the large effect of perseverance of individuals that led to the involvement of high officials and accompanying release of resources suggests that earlier and stronger involvement of client organizations has potential in fostering bottom-up innovations that contribute to the transition towards a circular infrastructure sector.

Keywords: innovation; circular economy; mission-oriented; viaduct; process analysis

INTRODUCTION

With a share of 33.5% of the total waste generated, the European construction sector was in 2014 responsible for approximately 870 million tonnes of the total waste generated (EPRS, 2017). In addition, the sector is responsible for an estimated 50% use of raw materials (Hu *et al.,* 2010), including critical materials such as copper (Jensen *et al.,* 2020). This is one of the reasons that, since the publication of the Ellen MacArthur Foundation report in 2015 (Schulze, G/EMF, 2016), the Circular Economy (CE) gained popularity in the construction sector as an economic ideology to achieve a healthy economy within the planetary boundaries (Desing *et al.,* 2020). Since its introduction, CE gained interest of national and international governments. The effects of these policies are already visible in the Dutch infrastructure sector, where

[1] t.b.j.coenen@utwente.nl

Coenen, T B J, Volker, L and Visscher, K (2021) Introducing Circular Innovation in the Construction Industry: The Case of the Circular Viaduct *In:* Scott, L and Neilson, C J (Eds) *Proceedings of the 37th Annual ARCOM Conference,* 6-7 September 2021, UK, Association of Researchers in Construction Management, 624-633

the number of developments with circular ambitions has grown exponentially (Rijkswaterstaat, 2020). These circular solutions aim foremost at reuse and recycling technologies, but increasingly include process-oriented and social solutions, such as procurement methods, design principles, asset lifecycle management, data management and assessment methods.

Because CE "replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes" (Kirchherr *et al.,* 2017, p.229), it demands not just a change in particular technologies, but a sector-wide transition, including economic, social and institutional aspects. Specific circular technologies have been studied separately, but how these relate to the wider transition towards a circular infrastructure sector remains largely unexplored (Hossain *et al.,* 2020). This is a far-reaching gap, because without a systemic view of the transition, as well as the innovations that constitute it, both the societal challenge and solutions remain ambiguous (Blomsma and Brennan, 2017).

In this research, a specific circular innovation was studied: A Dutch viaduct that was designed using circularity principles from its first idea up to the execution and follow-up initiatives, called the "Circular Viaduct" (CiVi). The CiVi is a typical example of an innovation that addresses circular challenges in the construction industry. It can be considered a mission-oriented innovation that contributes to pre-defined societal benefits beyond efficiency, cost reduction or competitive advantage (Hekkert *et al.,* 2020). The collection of such circular innovations and changes constitutes the wider systemic transition. Studying the unique circular innovation case of the CiVi from a MIS perspective provides insights into drivers and barriers which helps researchers and policy makers to study and govern future circular innovations more effectively.

To study such circular innovation trajectories within its context while being comparable to other trajectories, a research framework needs to be defined. The collection of developments in the direction of a particular societal challenge, including not only the new technologies itself, but also changes in the legislations, behaviour, (organizational) processes, actor relations and wider infrastructure, are together part of a transition towards the societal mission. Collections of these aspects are known as socio-technical systems (Geels, 2005). The concept of technological innovation systems (TIS) builds upon this notion and is employed to study developments of particular technologies and the structure and dynamics of the systems in which they are embedded (Carlsson and Stankiewicz, 1991). More recently, Hekkert *et al.,* (2020) introduced the mission-oriented innovation system (MIS) concept to study systemic change in a specific pre-defined direction, such as circularity. The MIS framework can be largely regarded as a multi-TIS framework using essentially the same methods of analysis to study the system dynamics and interactions. Next to the introduction of new technologies, the MIS also takes novel process and social innovations with a particular directionality into account (Wesseling and Meijerhof, forthcoming). Central to this concept is the structure and alignment of the socio-technical aspects, which are depend on the sectoral, domain or spatial dimensions. The MIS is hence applicable to each unique context, including the construction industry.

At the heart of the analysis of a MIS lays the study of the dynamics in the system, which is determined on the basis of the presence, emphasis and relation between seven main system functions (see Table 1, amended from Wesseling and Meijerhof (forthcoming)). The central idea is that fulfilment of each function is required to form a healthy innovation system. These functions are substantiated in concrete activities or events, which are collections of incidents or occurrences that took place in a certain moment in time. The functions can be present in different degrees and affect the attainment of the mission either positively, neutrally or negatively. In a MIS, these functions are not isolated, but acquire meaning through causal relations to the other functions and other events. Here, the functions are derived from the micro-dynamics in the trajectory, while these dynamics explain the hampering or acceleration of the innovation and change processes known as "motors of innovation" (Suurs, 2009).

Table 1: Description of the systems functions for the MIS analysis (amended from Wesseling and Meijerhof, forthcoming)

Code	Function	Function description and examples
F1	Entrepreneurial activities	Activities, initiatives, experiments, pilot projects, market introductions, novel business models of market players regarding new (clusters of) solutions towards the mission.
F2	Knowledge development	Creating knowledge on the problems and solutions "by research" and "by doing", including forecast studies, lab work, working groups and strategic studies.
F3	Knowledge diffusion (through networks)	Dissemination of knowledge regarding the problems and solutions through media, stakeholder meetings, knowledge networks, governance structures, publications and "learning by interaction".
F4		
F4a	Problem directionality	Formulation of the societal problems with respect to the mission and the priority in relation to other (societal) challenges.
F4b	Solution directionality	The efforts made to provide direction towards the mission goals in terms of (clusters of and coordination between) solutions and their priorities.
F4c	Reflexive governance	Monitoring, evaluation, impact assessment and anticipation of the progress to provide input for guidance towards the mission achievement. This is also understood as second-order directionality.
F5	Market formation and destabilization	Creation of conditions such that new solutions can compete with existing practices, e.g. by the creation of "mission arenas", business models and pricing mechanisms, as well as phasing out and destabilizing undesired markets with respect to the mission.
F6	Resource (re)allocation	Mobilization of financial, human and material resources to facilitate the other system functions and withdrawal of resources that support undesired activities with respect to the mission.
F7	Creation and withdrawal of legitimacy	Establishing and eliminating legitimacy for the initiation and prioritization of problems and solutions through raising awareness, stakeholder engagement, lobbying, championing, etc.

Case introduction: The Circular Viaduct

To study the micro dynamics in the transition processes towards a circular infrastructure sector, a single trajectory of a circular infrastructure innovation was analysed in-depth. The Circular Viaduct (CiVi) is a modularly designed and built viaduct that through disassemble-ability decreases the chances of pre-end-of-life demolition. The innovation was initiated by a medium-size Dutch contractor who was exploring innovative way to design in the Netherlands and stated in 2015 to aim to become the "most sustainable contractor" in the Dutch construction sector. While starting off with only a handful of individuals within a contractor organization, it began slowly involving enthusiasts from the client organization (i.e. Rijkswaterstaat - Dutch governmental infrastructure agency), concrete element suppliers and engineering firms. After the formalization process, it grew into a network of actors comparable to a regular small infrastructure construction project.

After the allocation of funds and a construction location by the client, the innovation system was further formalized by means of a collaboration agreement. In 2017, Rijkswaterstaat (the Dutch governmental infrastructure agency) initiated so-called living labs to create protected spaces for innovative experimentation. Although the CiVi was not officially selected as one of these living labs, it was regarded in a similar way. As such, it gradually became part of the circularity agendas and strategies within the infrastructure agency because of the alignment with the existing circularity strategies and policies. The eventual CiVi was located on a construction site of the Reevesluis near Kampen, a medium-sized city in the Dutch province of Overijssel. The completed CiVi was delivered in the beginning of 2019. Currently, the CiVi is regarded as one of the only integrally circular innovations in viaduct construction and it has, since the official opening in 2019, been promoted as flagship of circular bridge and viaduct construction in the Netherlands (TCB, 2019).

After the viaduct was delivered - and when the project success became clear - follow-up initiatives were organized through network events involving dozens of contractors, advisors, suppliers and public clients, as well as environmental, financial and legal experts. As a result of these network events and explorations, so-called “Small Business Innovation Research” (SBIR) tenders were commissioned by the infrastructure agency, which are innovation-oriented tender competitions to actively promote innovation with specific goals in mind. These resulted from 2020 onward in the initiation of several other projects involving circularly designed viaducts.

The narrative of the mission-driven innovation process was reconstructed by employing the MIS framework. Following Wesseling and Meijerhof (forthcoming), the performance of the MIS was analysed in three steps: (1) problem-solution analysis; (2) structural system analysis; and (3) systems function analysis. First, the problem-solution analysis was studied by relating the societal problems to the envisioned mission by studying policy and project documents. Second, the structure of the studied system was determined by creating an overview of the parties involved in the actual trajectory (mission arena) and contrasting those to the wider infrastructure system. Third, the functional analysis has been executed, to study the underlying dynamics of the trajectory. The paper will focus on the results of the third step.

In order to find the underlying dynamics of the case, the events and their connections were determined. Therefore, the events and their connections were identified by studying progress reports, project notes and evaluation reports as well as by conducting five interviews with key individuals in the trajectory. An important source for the reconstruction of the trajectory was the "Learning History" evaluation study (Rijkswaterstaat, 2019). The interviews included an initiator, the technical manager, the sustainability advisor, and senior CE advisor. These various data sources proved sufficient to create a complete and validated overview of the trajectory.

As a first step in the analysis of the CiVi trajectory, the processes were reconstructed and mapped as an event sequence consisting of almost 100 unique events. To be able to identify dominant function sequences, data needed to be quantifiable, which demanded a comparable unit of analysis. The events were hence coded into second-order codes (Saldaña, 2013), whereupon these were linked to the functions presented in Table 1 using the Atlas.ti software tool. This resulted in an extensive overview in which the sequence of functions became apparent. Finally, in addition to the functional overview, the full narrative was chronologically classified into phases in order to analyse the temporal overview and overarching dynamics (Poole *et al.,* 2000).

To determine and analyse the overall dynamics, the presence of both the functions and the particular sequences of functions were compared with “motors of change” in literature (Van de Ven and Poole, 1995). These motors are the causal relationships between functions that reinforce one another (Suurs, 2009). An example of such relationship is the creation of legitimacy (F7) that is required before resources are allocated (F6). In order to determine such relations of functions within the narrative, sequences based on two functions were determined using first-order Markov chains. In addition, a gamma analysis was conducted to determine the dominance of particular time sequences of functions. The gamma analysis shows to what extent a function precedes another and vice versa. Through the connection between each function, event and original source data, the underlying mechanisms of the most striking results of the quantitative analyses were studied in depth. This provided insights into the conspicuous developments of the CiVi trajectory and revealed explanations.

RESULTS

Narrative of the innovation trajectory

Throughout the CiVi trajectory, five phases were identified by pinpointing moments in the narrative in which the rate of progress radically changed: (1) idea and start; (2) initial attempt and muddling through; (3) further formalization steps; (4) successful attempt and execution; and (5) follow-up initiatives. Below, the narrative of the most striking aspects of the event sequences is presented and indicated by the functions in Table 1. Collections of events are mapped per phase in Fig 1.

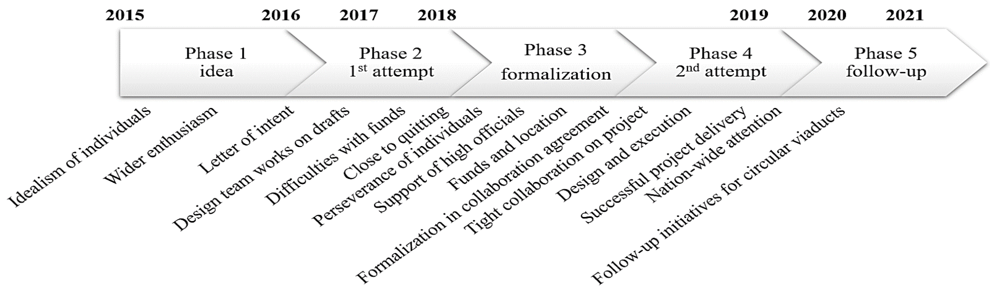

Fig 1: Overview of main events per phase in the CiVi trajectory

Findings indicate that during the course of 2014 and 2015, a manager within a Dutch contractor firm initiated the idea for a circular approach to infrastructure as a response to personal wider environmental concerns. In this initial phase, a small thematic group at the contractor explored both the meaning and fundamental problem of CE (F4a) and its potential solutions for infrastructure (F4b). Given that the theme "circularity" was rather new at the time, knowledge on both circularity and its implementation in infrastructure was developed (F2). After some initial ideas and sketches on circular design, in 2016, the manager of the contractor firm approached a sustainability manager of the infrastructure agency to discuss and explore opportunities for circular infrastructure (F3). In the meantime, potential solutions were further explored, while the resulting knowledge was shared and discussed within a small group, including an engineering firm, concrete supplier, knowledge organization and infrastructure agency, in order to explore opportunities for implementation in practice (F3, F4b), These actors knew each other from the national sustainable concrete programme "Green Deal verduurzaming betonketen". Eventually, a letter of intent was drafted by the contractor firm and signed by the contractor, two advisory firms, a sectoral research institution, a supplier, and the infrastructure agency as a pseudo-formal "consortium". This document stated that all undersigned parties would commit to put effort in designing and delivering a circular viaduct. In the second phase, the ideas were developed further by the consortium (F2, F3) and it was attempted to operationalize the ideas and knowledge into an actual project (F1, F4b). However, because lack of funds and commitment at the client side at that time (-F6), the project almost ended there, which had a discouraging effect on the individuals involved.

However, due to the perseverance of several individuals at the contractor and at the client organization, support of a high official in the client organization was found (F7), which resulted in the creation of a business case (F5). As the high official put it: "the enthusiasm of [three initiators] infected me. Indeed, it was the right time for a real product". The infrastructure agency allocated funds, people and a location for a project (F6). However, due to procurement legislation, the innovation could not be purchased as a regular project, and it was shaped as a collaboration agreement (F5). Consequently, the revived motivation led the individuals to design and plan a concrete and feasible solution for a modular viaduct aimed at flexibility and reusability (F1).

After the modest involvement of the client organization resulted in difficulties regarding project requirements and technical norms, the client organization allocated people to the project, which helped the project getting closer to operationality. Increasingly, the solution space got narrowed down towards standard viaduct girder segments and the preliminary designs were finished collaboratively in 2018 (F1, F4b). One of the people from the contractor illustrated the dependence on individuals' motivation and collaborative nature of the project as: "I have never collaborated so closely with three different parties. […] Everyone did it as a side project and had actually 'too' little time." Yet, despite some minor technical and time-related problems, the bridge parts were successfully designed, produced in a factory in this fourth phase, and assembled at the location by the segment supplier (F1). During installation of the viaduct segments, a monitoring system was set up by an external company to track the structural behaviour of the CiVi (F4c). The finished viaduct, which was officially opened in January 2019, was - and still is - considered a major achievement throughout the sector, as indicated by the appearance of national media and high officials, among which a state secretary, during the opening (F3, F4b, F7).

The story continues, because in the fifth and final phase of the trajectory, the client organization established, together with other parties involved in the CiVi trajectory, a central platform to structure and share the lessons learnt. In this "Open Learning environment" and several adjacent networking events, the lessons were shared and future directions for circular viaducts were explored (F3, F4b, F4c). At the same time, the process was reconstructed and meticulously reported in an evaluation booklet called the Learning history Circulaire Viaduct (F4c, F3). The widely shared enthusiasm and shared circularity goals (F7) led to relatively easy access to public funds (F6). The infrastructure agency initiated several unique yet large Small Business Innovation Research (SBIR) tenders, which resulted in thirty submissions by market consortia (F5). The main goal here was to explore further solutions towards circular design, construction, management and operation of viaducts (F4b, F2). From the ten initial winners who got the opportunity to develop their ideas further, three winning consortia were selected in the beginning of 2021 with each a unique and innovative circular viaduct design (F5). Throughout 2021, the three selected consortia are developing their new ideas regarding circularizing more viaducts (F1, F4b, F2).

Dynamics in the trajectory

The narrative of the trajectory shows a high dependence of project progress on individuals, particularly in the early stages of the project. As one of the circularity experts at the infrastructure agency put it: "The fact that there is now this circular viaduct can be fully attributed to the idealism and perseverance of [the initiating individual at the contractor firm] who kept pushing and inspiring others - particularly in the early project stages". While a lot of time and effort was put into the design and production of the viaduct segments, the moments in time in which the continuity was jeopardized were mostly due to a lack of funds and legitimacy. Furthermore, the end-product and its media and political attention worked as a catalyst for further explorations towards circular design, construction and management of viaducts. In other words, the CiVi itself, which has only been implemented as a temporary viaduct on a particular construction site, had in itself barely impact on the overall infrastructure resource and waste savings. Yet, it created wide interest and boosted further developments that aim for large future impact in viaduct construction and has contributed to the directionality of circular solutions.

Given the high dependence on public funds in the infrastructure sector, the progress of the trajectory depended very strongly on the prospect for a project, including funds and a physical location. Availability and allocation of resources did not directly result in the initiation and direction of circular solutions in the CiVi trajectory, yet it did strongly determine whether and to what extent next steps were taken in terms of design and construction - also with respect to adapting legislation and stimulating collaboration. The allocation of these funds depended on the legitimacy, especially in the shape of high-level support at the client side. However, it seemed that the support of high officials, and hence legitimacy, was only gained after concrete solutions were designed. The mutual dependency between client legitimacy and maturity of the market solution turned out to be an important reinforcing loop in the CiVi trajectory.

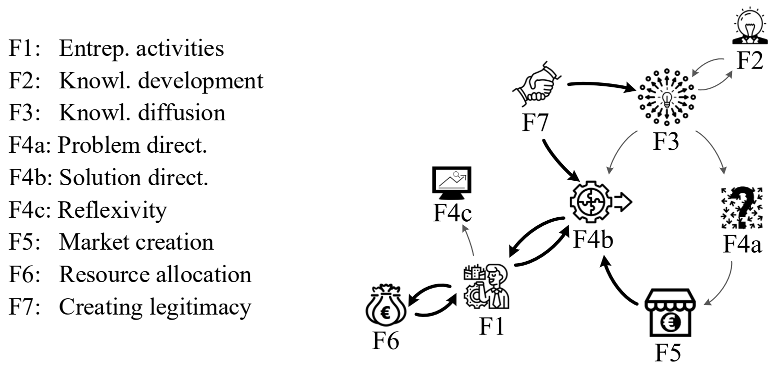

Fig 2: Sequences of functions in the CiVi trajectory analysis using a first-order Markov chain. The width of the arrows illustrates the number of occurrences.

Dominant function sequences and motors of change

By using a first-order Markov chain, the individual sequences of events were analysed. Fig 2 summarizes the predominant sequences. It shows that there are strong reinforcing loops between solution directionality (F4b) and entrepreneurial activities (F1), and between entrepreneurial activities (F1) and resource mobilization (F6). However, the fact that the execution of a project in the construction industry is strongly dependent on the client, who both provides legitimacy and funding, explains that the creation of legitimacy (F7) and mobilization of resources (F6) are often one and the same act. The same goes for knowledge development (F2), knowledge diffusion (F3) and entrepreneurial activities (F1), where the market parties create knowledge about the solution space through design activities. Since these activities often correspond to the same thing, they do not appear in Fig 2 as linkages.

The results indicate that the MIS functions are strongly interwoven in events of the CiVi case. Particularly in early stages, the concerns of a single individual about the sustainability problems and rising CE concept resulted in a working group where the solution direction shaped the definition of the circularity challenge (i.e., modular design). The entrepreneurial activities that resulted stimulated the effort to develop the directions of solution further. However, according to all interviewees, the willingness to collaborate between parties that are usually opposed - particularly between client and contractors - was an important success factor. In this case, the embeddedness in the infrastructure agency strategies and policies only came after the first moves of the contractor. In other words, the initiator created its own market and provided an impetus for further developments. Yet, it was only able to execute the project after the legitimacy (which could be found in the "circularity" label attached to the project) and accompanying funds from the client organization. This strongly collaborative effort is also indicated by the interwovenness of the functions.

Despite the many events that contributed to the accomplishment of the CiVi, the lack of events that actively promoted the destabilization of current non-circular practices was striking. The trajectory was executed in a rather protected space, while, for wider diffusion, it will need to compete with incumbent, non-circular alternatives with lower investment costs and highly normalized ways of designing, producing and managing infrastructure. However, the SBIR trajectories, in which the CiVi contractor did strikingly not participate, offer opportunities to normalize these circular principles and to innovate on a process and institution level. The SBIR trajectories are hence promising steps in next innovation trajectories within this MIS, because the public client has supported these functions in a very early stage of the trajectory. In addition, several initiatives were launched nationally and internationally to consolidate the circular economy mission in construction and infrastructure. CE is also increasingly specified in infrastructure tenders and often additional resources are made available by client organizations to stimulate suppliers in offering for circular solutions. Nevertheless, other initiatives are launched in the wider MIS that aim to stimulate circularity by, for example, introducing procurement criteria that include circularity assessment methods to price non-circular practices in asset design (e.g. CB'23, 2019).

DISCUSSION

The narrative presented in the previous section is much alike innovation journeys (Van de Ven *et al.,* 2008), but the fact that it is aimed at the circularity mission, with a specific solution direction (modularity) has several implications for studying such innovations. First, the analysis has revealed that the shared mission towards a CE has been a crucial element for the allocation of funds and individual perseverance in several occasions. These aspects would have been difficult to uncover without the MIS framework. Second, the learning trajectory of exploring circularity in infrastructure appeared at least as important as the impact or the actual future uptake of the innovation itself. While the CiVi has, as an individual asset, not much impact on resource depletion, its way of thinking sparked novel initiatives across the sector that have the potential to change viaduct design more systemically. Third, by placing this innovation in the circularity transition context, it becomes clear that it encompasses but one of the many innovations and changes in the transition. For example, the CiVi trajectory has revealed that the existing technical legislation for viaduct design does not support circular decisions and, consequently, a working group has been started to revise this legislation. This is in line with the theory that transitions require changes in the encompassing socio-technical systems rather than single innovations (Geels, 2005).

While the technical and legislative challenges demanded creative solutions, it was the emergence of funds and support by higher officials that turned out to be critical for continuity, which only appeared after existence of draft ideas. This can be explained by the structure of the construction and infrastructure sectors in which the market is highly dependent on only several large public clients (Brandon and Lu, 2008). The unique opportunity for the construction and infrastructure sectors is the fact that legitimacy, solution directionality, resources and the ability to create markets is predominantly with one party - the public client - while it is also this client that largely defines the mission and sets the terms. As such, the role of public clients involves both serving public values and commissioning high-value assets (Kuitert et al., 2019). This offers opportunities for the clients to both take a leading role in the CE transition and to create the conditions for market initiatives on an asset level.

CONCLUSIONS

In this study a unique infrastructure development trajectory was studied in-depth to find both how circular innovations evolve in the construction industry and how they differ from regular innovations in the sector. It shows that, despite the embeddedness of circular goals as well as a coherent circularity strategy at the client side, it can be difficult to acquire funding for circular innovations that do not originate in such strategy. To achieve the mission of making construction more circular, frontrunning innovation projects are needed. Such market-initiated projects run into difficulties regarding existing structures of procurement law and innovation processes but can be successful when they are sufficiently developed to convince public clients that they will contribute to the missions while accepting the risk inherent to radical innovation. Key drivers for project success appeared to be the creation of legitimacy through the support of high officials at the client side as a result of strong perseverance of individuals. To further theorize mission-oriented innovation in a construction context, comparison with other types of circular innovations is needed, such as circular business models, process innovation and social change. Such comparisons could contribute to understanding the circularity transition and to develop policies that aid in meeting the long-terms goals on circularity in the infrastructure sector.

REFERENCES

Blomsma, F and Brennan, G (2017) The emergence of circular economy: A new framing around prolonging resource productivity, *Journal of Industrial Ecology*, **21(**3), 603-614.

Brandon, P and Lu (Eds.), S-L (2008) *Clients Driving Innovation*, Chichester, UK: John Wiley And Sons Ltd.

Carlsson, B and Stankiewicz, R (1991) On the nature, function and composition of technological systems, *Evolutionary Economics*, **1**, 93-118.

CB'23 (2019) Kernmethode voor het meten van circulariteit in de bouw.

Desing, H, Brunner, D, Takacs, F, Nahrath, S, Frankenberger, K and Hischier, R (2020) A circular economy within the planetary boundaries: Towards a resource-based, systemic approach, *Resources, Conservation and Recycling*, 155, 104673.

Schulze, G (2016) *Growth Within: A Circular Economy Vision for a Competitive Europe*. Ellen MacArthur Foundation and the McKinsey Center for Business and Environment,1-22.

EPRS (2017) *Towards a Circular Economy - Waste Management in the EU European Union* Brussels: Directorate-General for Parliamentary Research Services (European Parliament) , Oakdene Hollins , Wuppertal Institute.

Geels, F W (2005) The dynamics of transitions in socio-technical systems: A multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860-1930), *Technology Analysis and Strategic Management*, **17(**4), 445-476.

Hekkert, M, Janssen, M J, Wesseling, J H and Negro, S O (2020) Mission-oriented innovation systems, *Environmental Innovation and Societal Transitions*, **34**(November 2019), 76-79.

Hossain, M U, Ng, S T, Antwi-Afari, P and Amor, B (2020) Circular economy and the construction industry: Existing trends, challenges and prospective framework for sustainable construction, *Renewable and Sustainable Energy Reviews*, **130(**June), 109948.

Hu, M, van der Voet, E and Huppes, G (2010) Dynamic material flow analysis for strategic construction and demolition waste management in Beijing, *Journal of Industrial Ecology*, **14(**3), 440-456.

Jensen, P D, Purnell, P and Velenturf, A P M (2020) Highlighting the need to embed circular economy in low carbon infrastructure decommissioning: The case of offshore wind, *Sustainable Production and Consumption*, **24**, 266-280.

Kirchherr, J, Reike, D and Hekkert, M (2017) Conceptualizing the circular economy: An analysis of 114 definitions, *Resources, Conservation and Recycling*, **127(**April), 221-232.

Kuitert, L, Volker, L and Hermans, M H (2019) Taking on a wider view: Public value interests of construction clients in a changing construction industry, *Construction Management and Economics,* **37(**5), 257-277.

Poole, M S, Van de Ven, A H, Dooley, K and Holmes, M E (2000) Phasic analysis, *In*: (Eds.) *Organizational Change and Innovation Processes: Theory and Methods for Research*, Oxford: Oxford University Press.

Rijkswaterstaat (2019) *Een Learning History - Wat Leert Het Eerste Circulaire Viaduct Ons?* Utrecht: Ministerie van Infrastructuur en Waterstaat.

Rijkswaterstaat (2020) *De Toekomst Begint Nu - Jaarrapportage Impulsprogramma Circulaire Economie 2019*, Utrecht: Ministerie van Infrastructuur en Waterstaat.

Saldaña, J (2013) *The Coding Manual for Qualitative Researchers 2nd Edition*, London: SAGE.

Suurs, R A A (2009) *Motors of Sustainable Innovation (Proefschri)*, Netherlands: Universiteit Utrecht.

TCB (2019) *Naar Een Circulaire Bouweconomie*, Transitiebureau Circulaire Bouweconomie, Available from: https://circulairebouweconomie.nl/wp-content/uploads/2020/03/Uitvoeringsprogramma-Circulaire-Bouweconomie-2019.pdf [Accessed 8 July 2021].

Van de Ven, A H and Poole, M S (1995) Explaining development and change in organizations, *Academy of Management Review*, **20(**3), 510-540.

Van de Ven, A, Polley, D, Garud, R and Venkataraman, S (2008) *The Innovation Journey*, New York: Oxford University Press Inc.

Wesseling, J H and Meijerhof, N (n.d.) Development and application of a Mission-oriented Innovation Systems (MIS) approach, *Environmental Innovation and Societal Transitions*, 1-24.