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Circular economy in urban projects: a case studies analysis of current practices and tools

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Abstract: Over the last decade, the concept of circular economy has gained momentum among practitioners, politicians and scholars thanks to its promise of achieving sustainability goals. However, there remains a need to demonstrate and assess its positive environmental impacts. With respect to the building sector, circular economy is still a relatively new topic. To date, research has tended to focus primarily on the macro-scale (cities or eco-parks) and micro-scale (manufactured products or construction materials). Nevertheless, the often-neglected built environment is also expected to play a crucial role due to its high contribution to various environmental impacts.

Accordingly, this paper aims to contribute to this growing area of research by reviewing four case studies of 'circular neighbourhood' projects in Europe. First, a conceptual framework analysis is defined and applied to the cases. Second, circular economy initiatives and actions are identified and classified using interviews and document analysis. Third, the use of assessment tools within these circular economy projects is investigated. The results demonstrate a diverse representation of the circular economy paradigm and a growing role played by the assessment tools.

Keywords: Circular Economy; Life Cycle Assessment; Urban Project; Circular neighbourhood.

Introduction

Over the last 10 years especially, the concept of a circular economy (CE) has been gaining momentum in politics, business and academia (Reike, Vermeulen, and Witjes 2017; Kampelmann 2016) in the pursuit of overcoming the contradictions between economic and environmental prosperity (Geissdoerfer et al. 2017). Indeed, the current economic model, which can be characterised as 'linear' based on a 'take-make-consume-throw away' approach of resources, is presently reaching its limits. Conversely, the CE forms an "economic system of trade and production which, at all stages of the product lifecycle, aims to increase the efficiency of resource use and reduce the impact on the environment, while developing the well-being of individuals" (ADEME 2014). For these reasons, CE already represents the core theme of major European plans and regulations (Petit-Boix and Leipold 2018), such as the 'Circular Economy Package' adopted in 2015.

Today, CE is studied by several disciplines ranging from economics to urban planning, though it remains closely linked to sustainable development issues (Kirchherr, Reike, and Hekkert 2017). However, to date, no univocal and shared definition of CE has yet been developed, despite a wide dissemination of the concept (Prieto-Sandoval, Jaca, and Ormazabal 2017). Thus, CE constitutes an

evolving notion (Merli, Preziosi, and Acampora 2018), rather ambiguous and vague (Korhonen et al. 2017).

The built environment, given its important contribution to several environmental issues, is supposed to comprise one of the main targets of CE strategies. However, current scientific literature on this subject remains limited, and concrete application of the principle is slow to be implemented (Densley Tingley, Giesekam, and Cooper-Searle 2018; Adams et al. 2017; Pomponi and Moncaster 2017). Furthermore, little general consensus exists concerning how to best approach and deal with this concept, and the knowledge and tools required to enact it remain to be developed (Leising, Quist, and Bocken 2018).

This is especially true for the building sector, to which CE remains a relatively new topic (Adams et al. 2017; Bocken et al. 2017). Furthermore, there is still a need to demonstrate and assess its positive environmental impacts. Indeed, implementing CE initiatives not only generates potential benefits, but also a number of environmental risks. ‘Closing the loop’ does not always positively affect the environment, and therefore, ‘circularity’ should be analysed against relevant indicators (Petit-Boix and Leipold 2018; Kampelmann 2016). In addition, it is also necessary to ensure that the most environmentally relevant initiatives are realised. For this reason, the need for systemic methods and tools to validate the environmental relevance of the CE applied to the built environment is now evident (Haupt and Zschokke 2017; Haupt, Vadenbo, and Hellweg 2017).

Accordingly, this paper aims to contribute to this growing area of research, which currently remains in its infancy. The results indicate a diverse representation of the CE paradigm and confirm that assessment tools could bring a useful contribution because if CE remains a vague trendy expression, there is a high risk of greenwashing. Life cycle assessment (LCA) appeared in the early 1990's and even if the expression CE was not used at that time, most ideas corresponding to CE were already integrated. For instance, recycling was one of the aspects studied in order to reduce environmental impacts of the built environment. A method has been elaborated that accounted, among other aspects corresponding to the CE approach, for environmental benefits of recycling at the fabrication stage but also after deconstruction (Polster, 1996).

CE in the built environment: from the ‘circular city’ to the ‘circular neighbourhood’

As mentioned, the CE approach is gaining momentum in the field of urban sustainability. Several studies, as well as some international meetings, have investigated the role that the CE can play in ensuring a more sustainable city, and the literature on this subject continues to grow (Cities Foundation 2017; Ellen MacArthur Foundation 2017; Prendeville, Cherim, and Bocken 2018).

According to Pomponi and Moncaster (2017), three scales of CE deployment can be identified from the scientific literature: the ‘macro scale’ of the city, the ‘meso scale’ of the buildings, and finally, the ‘micro scale’ of the construction elements. However, while academic research is more consistent concerning the macro scale (particularly in urban metabolism and eco-parks), as well as the micro scale (particularly in materials and building components), the meso scale remains poorly explored (Pomponi and Moncaster 2017).

Considering their pressures on the environment, to date, the scientific literature on CE has focused more attention on the ‘circular city’ topic.

Several cities, such as Berlin, Rotterdam, Paris, London, Milan and Amsterdam, have recently adopted strategic plans and are launching specific actions and projects to make their economy more circular. In 2014, for instance, the city of Amsterdam adopted ‘The Circular Metropolis Amsterdam 2014–2018’¹, a strategic document aimed at transforming the city into a competitive and sustainable European metropolis. This document, which comprises part of the Amsterdam Smart City initiative, is based on the ‘The City Circle Scan’ approach, enabling areas to be identified where major CE progress can be made. Thanks to this tool, Amsterdam has decided to focus on the construction sector as well as the organic production and biomass sector. In addition, in 2016, Amsterdam became a Fab-City, an international initiative bringing approximately 20 cities together with the goal of becoming self-sufficient². Similarly, the city of Rotterdam also linked the EC to the smart city initiative, adopting the ‘Roadmap Circular Economy Rotterdam’³ in 2016. The proposed actions to ensure the city’s sustainable and circular development by 2030 are based on the results of the ‘Rotterdam Metabolism’ study, which provided a comprehensive picture of urban flows. Rotterdam’s EC strategy focuses primarily on the city’s port area for implementing biosourced projects (Prendeville, Cherim, and Bocken 2018).

More recently, London and Paris also presented guidance documents in 2017. Following the 2015 General Assembly of the Circular Economy, Paris adopted its first ‘Circular Economy Plan 2017–2020’⁴ and its operational roadmap. London similarly published a ‘Circular Economy Route Map’⁵, containing actions involving the construction, food, textile, plastic and electrical industries. This document is accompanied by an economic analysis, which estimates the benefits to the economy in terms of wealth creation, activities and employment at £2.8bn.

Initiatives and actions are multiplying and global networks are being created, bringing together several cities. The Circular Europe Network (CEN)⁶, for example, brings together dozens of European cities to promote the exchange of best practices. At the international level, the Open Source Circular Economy (OSCE)⁷ collects innovative solutions linking EC and open data.

Otherwise, current research on CE has dedicated little attention to the meso scale, whereas some authors have stressed the importance of orienting CE research towards the built environment (Leising, Quist, and Bocken 2018; Pomponi and Moncaster 2017; Glass, Greenfield, and Longhurst 2017). Indeed, in Europe, the built base represents almost half of the total energy consumption, and more than 50% of all extracted materials (European Commission 2011). In France, nearly 40% of energy consumption and 60% of electricity are attributed to this, which is also responsible for the emission of approximately a quarter of national greenhouse gases (ADEME 2012). In addition, the construction sector generates nearly three-quarters of the national waste⁸ volume and consumes approximately 600 km² of natural areas per year⁹.

¹ <https://amsterdamsmartcity.com/circularamsterdam>

² <http://fab.city/>

³ <https://www.pianoo.nl/sites/default/files/documents/documents/rebusfactsheet37-gemeenterotterdam-engels-juni2017-1.pdf>

⁴ <https://www.paris.fr/economiecirculaire>

⁵ <https://www.lwarb.gov.uk/what-we-do/circular-london/circular-economy-route-map/>

⁶ <http://www.circular-europe-network.eu/>

⁷ <https://oscedays.org/>

⁸ <http://www.statistiques.developpement-durable.gouv.fr/lessentiel/ar/326/1097/dechets-secteur-construction.html>

⁹ <http://www.developpement-durable.gouv.fr/Etalement-urbain-et.html>

In this context, the built environment could truly represent an essential cornerstone for implementing effective CE strategies in the city. Concerning the meso scale, several authors have pointed out that the ‘neighbourhood scale’, the link between the city and the building, is the most relevant for addressing numerous environmental problems (Lotteau 2017). In Europe, the attention paid to the neighbourhood scale has even become central to the sustainable city discourse (Souami 2009). By contrast, however, limited research has been conducted concerning the application of CE principles in neighbourhoods, and there is a lack of comprehensive studies summarising recent development. Nevertheless, a number of pathfinder projects are beginning to emerge in the practice. Assessment tools have been developed (Popovici et al., 2004; Herfray et al., 2010; Roux et al., 2013) and applied to the design at neighbourhood scale in Lyon, Champs sur Marne and Paris (Peuportier et al., 2005; 2012 and 2015).

On these bases, the present paper aims to address the two following questions:

Q1) How can the CE be implemented in a neighbourhood?

Q2) What assessment tools are used?

Methodology

The study proposes analysing and comparing four case studies concerning a ‘circular neighbourhood’. The case study method was selected because this enables integrating theory and practice, aptly suiting the exploratory nature of this research (Leising, Quist, and Bocken 2018).

To begin, a literature review was undertaken to identify relevant ‘circular neighbourhood’ cases. Attention was dedicated not only to scientific papers, but also to other types of documents, such as reports and urban planning documents. Indeed, scientific literature was mostly limited to theoretical discourse and only little attention was given to the neighbourhood scale. The research was conducted in English, French and Italian. A total of only four case studies were found and selected: the first case concerns the neighbourhood of Buiksloterham (Amsterdam), which will develop into a sustainable district based on circular principles; the second neighbourhood is Kera (Espoo), an industrial area destined to become a ‘liveable circular economy neighbourhood’; the last two cases are based in Paris, namely, the Groues and Saint-Vincent-de-Paul eco neighbourhoods, both considered an ‘EC living lab’. All these cases were selected on the basis of two fundamental criteria: the willingness to implement the principles of the CE at the neighbourhood scale and the presence of a comprehensive CE strategy at the city level, within which the project fits in.

Following the case selection, CE initiatives and actions were identified and classified using document analysis and integrating data collected through semi-structured interviews with local stakeholders involved in the projects.

Finally, a conceptual framework analysis was defined based on three main criteria: CE practices, strategic city scale integration, and tools employed. This analytical framework has been applied to the four case studies in order to compare them.

Case studies analyses

Four case studies were selected based on their innovative character and central relevance of the CE. Indeed, in all these cases, CE is put forward as one of the key pillars for the urban projects.

Case	Buiksloterham	Kera	Les Groues	Saint-Vincent-de-Paul
City and Country	Amsterdam, Netherlands	Espoo, Finland	Nanterre, France	Paris, France
Size	1000 hectares	22 hectares	65 hectares	4 hectares
Site	Requalification industrial areas	Requalification industrial areas	Requalification industrial areas	Requalification hospital complex
Main Objectif	“key innovation zone for circular development”	“a showcase district for circular economy”	“circular economy living-lab”	“a privileged space to develop and test circular economy”
Starting date	Around 2015	Around 2018	Around 2018	Around 2018

Table 1. Case studies.

As illustrated in Table 1, despite the differences in size and location, the analysed neighbourhoods present some common features. For instance, all four cases constitute urban regeneration projects, and at the same time, they are also experimental and function as showcases to test the CE principles. Moreover, it is important to underline that all the projects are recent and have not yet been carried out or completed. For this reason, this analysis can only be based on the design phase.

Buiksloterham, Amsterdam

Amsterdam represents one of Europe’s pioneering cities in terms of CE. In fact, CE comprises one of the main pillars of the Sustainable Amsterdam Agenda (2015), which aims to, by 2020, reduce energy consumption by 20% and increase renewable production by 20% compared to 2013 (van der Hoek, Straker, and de Danschutter 2017). In this strategic document, the Buiksloterham neighbourhood is considered “an engine for the broader transition of Amsterdam” (Metabolic 2015) towards a circular city.

Part of a larger redevelopment plan of the northern banks of the river, Buiksloterham is characterised by abandoned factories, wastelands and docks. In the city’s vision, however, this neighbourhood, once the site of Amsterdam’s most polluting industries, can become “a key innovation zone for circular urban development” (Metabolic 2016). Furthermore, the municipality proposed a bottom-up approach for the area’s redevelopment in order to develop a more comprehensive sustainability strategy. For this reason, in 2015, the ‘Circular Buiksloterham Manifesto’ was signed by approximately 20 stakeholders, including local actors, organisations, associations and companies. This innovative manifesto includes the shared guiding principles for redeveloping Buiksloterham, such as the zero-waste objective, the implementation of clean technologies or the use of biosourced materials. Recognising the urgency for a clear operational strategy, all the stakeholders involved commissioned an Urban Metabolism Scan in order to understand the neighbourhood’s complete workings from a systemic perspective. The analysis, carried out by the Metabolic and published in 2015, was divided into three stages (context analysis, stakeholder analysis and metabolism analysis). This ‘Urban Metabolism Scan’ focused on material and energy flows, biodiversity, environmental conditions, socio-economic factors, local actors, urban planning documents and plans, health, and living environment.

Following this analysis, a study was conducted concerning the neighbourhood's CE potential. On these bases, the priority objectives for redeveloping Buikloterham as a 'living lab for CE' by 2034 were divided into eight priority issues (Table 2).

OBJECTIVES	
Energy	Buikloterham is energy self-sufficient with a fully renewable energy supply
Materials & products	Buikloterham is a zero waste neighbourhood that with a near 100% circular material flow
Water	Buikloterham is rainproof and has near 100% resource recovery from waste water
Ecosystems and biodiversity	Buikloterham's ecosystems are regenerated and its base of natural capital is self-renewing
Infrastructure & mobility	Buikloterham's Infrastructure is maximally-used and local mobility has zero emissions
Socio-cultural	Buikloterham has a diverse and inclusive culture, and a high quality, livable environment
Economy	Buikloterham has a strong local economy that stimulates entrepreneurship and encourages the creation and exchange of multiple kinds of value (social, environmental, cultural)
Health & wellbeing	Buikloterham is a healthy, safe and attractive environment with recreational activity space for all residents.

Table 2. Buikloterham's objectives.

In particular, with regard to the built environment, it is interesting to note that a 'Circular Building Standard' will be introduced for all renovations or new constructions. This innovative assessment tool, which is still in the development phase, would allow tax credits once the standard has been reached. Among the key recommendations, all building roofs are equipped for clean energy production and rainwater collection, and all materials are registered in a digital passport to facilitate their identification. In addition, prefabricated building elements are preferred, facilitating deconstruction and reuse.

To ensure these objectives, a first action plan was developed. The proposed actions consist of two types: systemic actions, aimed at ensuring the district's long-term transition, and technical actions, concerning more specific issues. For the definition of the actions, prioritisation work was carried out. In particular, the actions considered most urgent consist of those related to new construction and infrastructure. Consequently, the priority actions concern the energy efficiency of the built stock, the flexibility of new infrastructures, the development of fresh mobility, water recovery and management.

Kera, Espoo

The city of Espoo, Finland is one of the pioneering cities in terms of sustainable development, as demonstrated in a comparative assessment study of 15 European cities carried out in 2017 by the University of Tilburg¹⁰. Indeed, initiatives led by the municipality within the framework of the Helsinki Metropolitan Plan, as well as the Helsinki Metropolitan Area Smart and Clean Cooperation project, are multiplying, with the objective of becoming carbon neutral by 2050¹¹. In most cases, CE constitutes a central issue in these initiatives.

In this context, the Kera neighbourhood, located within the eastern part of Espoo and close to the rain station, represents a unique opportunity for the municipality to experiment in innovative CE solutions. Previously an industrial area, and the headquarters of the Finland's largest distribution group, Kera will thus be transformed into a mixed-use and dense neighbourhood of 14.000 residents. In addition to

¹⁰ <https://www.espooinnovationgarden.fi/en/espoo-innovation-garden/media/news/espoo-remains-the-most-sustainable-city-in-europe/>

¹¹ https://www.espoo.fi/en-US/Housing_and_environment/Sustainable_development

commercial services and offices, the project includes day-care centres, schools, sports and recreation services¹².

The municipality’s objective is to transform this industrial park into a liveable neighbourhood with a strong CE focus by 2035. The goal of this project is to make Kera “a showcase district for circular economy”¹³, as well as “an international example of circular economy”¹⁴. It is with this perspective that the case of Kera was presented as an example of a ‘circular neighbourhood’ at the World Circular Economy Forum of 2017¹⁵.

The ongoing project was the winner of the Kera Challenge¹⁶, launched in 2015 with the aim of identifying a vision and project for Kera’s future, based on the principles of sustainable urban planning and EC. In the winning project, Co-op City, CE is supposed to be achieved through a “large range of different measures, from boosting resources efficiency and creating closed loop systems to involving the local residents”¹⁷.

The main solutions to support circular economy put forward in the project were analysed and summarised in Table 3:

Green Infrastructure A network of multifunctional public places	Urban Fabric Sustainable Planning and Construction process	Function and Services Mobility Services in a 20 minute city Sustainable energy solutions	Social Environment Livability through co-creation
Ecosystem services Implement green and blue tools Design for multifunctional Evaluate generated values	Cyclical flexibility in buildings Material cycles Temporary use of the logistics Reuse and recycling of asphalt Recycling of the logistic halls	Mobile platforms for emerging services models Autonomous vehicle traffic Logistics Lab Access and smarter use of the spaces Smart parking and shared cars 100% renewable energy On site energy Smart energy grid Passive energy optimization	Participatory processes Common spaces Social engineers Affordable housing

Table 3. Kera’s EC actions.

In particular, with respect to the built environment, the EC practices to be implemented are contained within the ‘Kera Design Manual’. In the manual, all constructions are required to be biodegradable or fully recyclable in order to gradually phase out construction waste. Indeed, the flexibility of the constructed buildings represents one of the document’s first fundamental points. In fact, this flexibility provides the basis for the possibility of a future ‘circular regeneration’ of the built stock. In this perspective, LCA will be mandatory. In addition, for new constructions, all materials used are required to be fully biodegradable or recyclable in order to reduce construction waste.

¹² [https://www.espoo.fi/en-US/Housing_and_environment/City_planning/Master_Plan/Pending_Master_Plans/Component_Master_Plan_of_Kera/Kera_set_for_sustainable_growth\(105154\)](https://www.espoo.fi/en-US/Housing_and_environment/City_planning/Master_Plan/Pending_Master_Plans/Component_Master_Plan_of_Kera/Kera_set_for_sustainable_growth(105154))

¹³ <https://www.helsinkismart.fi/portfolio-items/an-industrial-area-turns-into-a-liveable-circular-economy-neighbourhood/>

¹⁴ https://www.espoo.fi/en-US/Jobs_and_enterprise/A_dynamic_city/Locate_in_Espoo/Urban_Development/Rail_Zone/Kera

¹⁵ <https://www.sitra.fi/en/projects/world-circular-economy-forum-2017/#wcef2017>

¹⁶ http://www.nordicinnovation.org/Documents/Nordic%20Built%20Cities-dokumenter/NBCC-Kera-COOP-CITY-booklet_small.pdf

¹⁷ <http://uusikera.fi/wp/wp-content/uploads/2016/06/COOP-CITY-Illustrations.pdf>

Concerning reuse and recycling, attention is paid to both existing materials, such as asphalt, which must be recovered, and to the construction elements of existing halls, such as beams, slabs and columns. In addition, the temporary use of some existing buildings is highlighted as an EC practice. For example, during the building construction, the ground floor of the halls will be used as for temporary storage for materials and elements to be reused or recycled. Furthermore, the halls' structure will be reused in constructing new buildings or outdoor spaces.

In addition, it is interesting to note that 100% of the primary energy demand will be produced from renewable sources, some of which will be produced on site. Solar, geothermal and wind energy are planned and will feed into an intelligent energy grid. For new constructions, passive solutions are preferred.

Les Groues, Nanterre

The urban redevelopment project of the Groues in Nanterre, led by the Etablissement Public d'Aménagement de la Défense Seine-Arche (EPADESA), aims to create a mixed district, offering housing, office space, shops, services and equipment and accommodating nearly 12.000 inhabitants and new jobs¹⁸. Near the business district of La Défense and served by a future line of the Grand Paris metro, the Groues neighbourhood, covering approximately 65 hectares, is characterised by numerous wastelands and distressed buildings. The project is recent, as is its realisation. In 2015, a Strategic Operational Project was approved by EPADESA, and in December 2016, the Concerted Development Areas (ZAC) were created. The first lots are currently being awarded, and the operation is expected to continue until 2030 (ADEME 2017).

The goal of the Groues development project is to become a “laboratory for a dynamic, green and inclusive neighbourhood”¹⁹, and more generally, to become “an experimental laboratory for the sustainable city of tomorrow”²⁰. In particular, the project aims to be exemplary in environmental matters and to obtain the EcoQuartier Label, becoming a positive energy territory²¹.

The project is based on five strategic axes:

Objectives				
Energy transition and the fight against climate change	Biodiversity and respect for natural resources	Protection against nuisances and creation of healthy and comfortable environments	Creation of an economic innovation ecosystem integrating a diversity of actors and co-design approaches	Laboratory of circular and solidarity economy

Table 4. Les Groues' objectives.

As such, CE represents one of the main pillars of the project's sustainable development strategy. Winner of the Call for Expression of Interest 'Circular Economy and Urban Planning' launched by the Ademe in 2015, the Groues project offers a place to experiment with a CE at the neighbourhood and territorial scale.

¹⁸ <https://fr.calameo.com/read/00398144113f3e65fce93>

¹⁹ EPADESA. 2016. Les Groues. Plan Guide.

²⁰ <https://fr.calameo.com/read/00398144113f3e65fce93>

²¹ <http://fr.calameo.com/read/0039814413c1330021bdd>

As presented in the figure above, the actions planned for CE are multiple. In particular, concerning the built environment, attention is paid to the local management of construction site waste (choice of materials, grey energy, local management of backfill/burial) (ADEME 2017). In addition, the ZAC project plans to place the built environment at the centre of EC's approach, as well as the project's overall energy efficiency ambition. To this end, 'lifecycle thinking' is encouraged here: "The building must be understood in all its spatial and temporal integrity by real estate operators, who must understand the lifecycle of their building: its manufacturing processes and materials, its duration over time and its capacity to adapt and evolve up to its deconstruction"²². In addition, the concepts of 'grey energy' and 'transformation capacity' are central. Other EC practices are highlighted as well, such as rainwater harvesting, building flexibility and modularity, neighbourhood waste harvesting and reuse of existing buildings.

In addition, in 2016, EPADESA launched two calls for projects, aimed at inspiring innovative reflections and experiments on the CE theme. The first one concerns temporary urban planning approaches, allowing the lifespan of existing buildings to be extended. The ephemeral initiatives presented were highly diverse, ranging from soil remediation to the reuse of building materials, or even innovative start-up incubators. The second one directly concerns new constructions and aims to develop innovative CE solutions in the construction sector. LCA has been applied to the design of 5 office buildings, and the environmental benefit of recycling has been studied.

Saint-Vincent-de-Paul, Paris

Located in the 14th arrondissement of Paris, the Saint-Vincent-de-Paul ancient hospital remained under decommissioning for approximately 10 years. In 2014, however, it was acquired by the municipality of Paris with the aims of transforming it into an innovative eco-neighbourhood (City of Paris 2017a). Covering an area of 3.4 hectares, the redevelopment project of the former Saint-Vincent-de-Paul Hospital represents a rare opportunity for urban transformation in the heart of Paris' particularly dense urban fabric.

In particular, the objectives pursued by Paris are as follows:

Objectives			
Create a predominantly residential area, promoting social diversity	Lead an exemplary environmental approach, making Saint-Vincent-de-Paul an innovative and emblematic eco-neighbourhood for the city	Think of public and open spaces as green spaces, whether on roofs, floors or facades	Enhance the heritage and history of the site

Table 5. Saint-Vincent-de-Paul's objectives.

In December 2016, the ZAC was created and granted to the developer Paris Batignolles Aménagement. The construction work began in 2018, and the planned programme provides for approximately 60,000 m² of total floor area, broken down in housing (including 50% social housing), facilities, equipment (including a school and a gymnasium), shops and a public garden²³.

²² EPADESA. 2016. Les Groupes. Plan Guide.

²³ <https://www.paris.fr/services-et-infos-pratiques/urbanisme-et-architecture/projets-urbains-et-architecturaux/saint-vincent-de-paul-14e-2373>

Concerning the built environment, the future district aims to become an exemplary showcase for the entire city thanks to an ambitious environmental approach. Specifically, as stated in the Resilience Strategy adopted in 2017, Saint-Vincent-de-Paul aims to be the city's first resilient and carbon-neutral neighbourhood (City of Paris 2017b). In compliance with the city's framework documents, the project thus aims to create a "pilot district for sustainable development" (City of Paris 2017a), reducing its impact on the environment and promoting innovative technologies while also involving the inhabitants. In this perspective, the new project provides for reversible buildings, pooling resources, converting 60% of existing buildings, developing renewable energies, certifying new constructions, optimising energy systems and recovering waste.

In addition, ZAC Saint-Vincent-de-Paul aims to be "a privileged space to develop the principle of CE"²⁴. Several different actions are being put forward in the field of CE, and the project must respect the orientations of the Parisian CE plan. With regard to the built environment, attention is being paid to reusing certain buildings, which would make it possible to limit demolitions, short circuits and temporary occupation of existing buildings, as well as to ensure continuity with the ephemeral urban planning experimentation of the Grands Voisins, including the smart grids, urban agriculture and bio-waste.

More specifically, regarding waste, more attention is paid to the construction phase, and the following objectives in particular:

- Source reduction of the quantity of waste;
- Material recovery by reuse in place or elsewhere (in particular, building elements such as doors, windows, etc., which can easily find a new use, or concrete waste and bricks, which can be used as aggregates);
- Energy recovery from waste;
- Storage in a technical centre, reserved for final waste.

To this end, a process of recovering dismantlable elements likely to be reused is planned for all site operations, thanks to an inventory distributed to various local, potentially interested structures. In this respect, a specific project management assistance service for sustainable development is planned from the project's amelioration. Applying LCA to the design of a project including deconstruction, renovation and new construction is planned in the frame of the PULSE-PARIS project funded by ADEME²⁵.

²⁴ http://www.paris-batignolles-amenagement.fr/pba/sites/default/files/publications/dp_svp_1506_deflite_bd.pdf

²⁵ The PULSE-PARIS research project aims to improve the relevance and operationality of eco-design approaches for urban projects in line with the CE strategic plans of the City of Paris. In particular, the project focuses on life cycle assessment (LCA) tools at the neighborhood scale, which are still in their infancy. The project will synthesise strategic approaches at the city scale and eco-design approaches on the urban project, in order to verify the coherence and articulation between these decision-making levels. The evaluation of CE practices on this scale using LCA is innovative and would make it possible to better understand the environmental benefits of these practices. (The research project is led by EIVP and MinesParisTech).

Cross-case comparison and discussion

The results of the analysis are summarised in Table 6 and are compared by applying the analytical framework based on the following criteria: CE practices, strategic city scale integration, and tools employed. Following this three-step analysis, some significant similarities have been pointed out.

	Buiksloterham	Kera	Les Groues	Saint-Vincent-de-Paul	
Strategic city scale integration	Sustainable Agenda Smart City Initiative Circular Amsterdam	Lien stratégie durabilité et smart city	EcoQuartier Label	Resilience Plan Territorial Climate Plan CE Plan	
Tools employed	Circular Building Standard Materials digital Passport MFA	Kera design manual LCA Buildings	(Perspective cycle de vie)	LCA Building Carbon Footprint Municipality's assessment tool	
CE practices	Energy	100% renewable energy PassivHaus Label Local energy production	100% renewable energy PassivHaus Label Local energy production (Géothermal, Eolic) Smart Grid	70% renewable energy	40% electricity by photovoltaic panels PassivHaus Label
	Waste and materials	100 % energy recovery from wastewater		Energy recovery from wastewater	Smart Grid
		Reuse materials		Reuse of materials and existing buildings	Reuse of materials and existing buildings
		100% « circular material flow »	Reuse materials and construction elements Biodegradable or recyclable materials	Local management of construction and demolition waste	Local management of construction and demolition waste
		Deconstruction Zero waste objectif		Waste recovery and valorisation	Waste recovery and valorisation
Water	Rainwater collection	« Green and Blue Tools »	Rainwater collection		
Other	Temporary occupancy of buildings Buildings flexibility Prefabricated constructions and structures Auto-construction Urban agriculture and local food production	Temporary occupancy of buildings Buildings flexibility	Temporary occupancy of buildings Buildings flexibility Urban agriculture	Temporary occupancy of buildings Urban agriculture Short circuits CE stakeholders point of reference	

Table 6. Cross-case comparison

First of all, the four projects are integrated into the strategic documents regarding the sustainable development and EC of each city, such as the Smart City Agenda, Climate Change Plan, and so on. Furthermore, in these documents, the projects are always presented as 'experimental demonstrators' of CE in urban projects. However, it is important to note that, in all the cases reviewed, CE is often seen as one of the pillars of sustainable development, and sometimes, no distinction is made among the proposed actions between those related to the CE or to sustainable development.

Second, the analogies are also evident with respect to CE practices identified in the projects. Following the case studies analysis, it is possible to classify four categories of recurrent practices: energy, water, waste and other. In particular, all cases insist on flexibility and temporary occupancy of buildings, the reuse of both building materials and existing buildings, and eco-construction. On this subject, an important focus is placed on the energy aspects of new buildings, with precise standards to

be achieved. Other practices highlighted by at least two cases relate to waste management, particularly construction site waste, as well as water management and urban agriculture.

More generally, the comparative table indicates that the vast majority of the CE practices highlighted by the cases focused more on environmental issues. In fact, the other two pillars, economic and social, would not appear to be central.

However, no consensus is present concerning the tools employed. The Dutch and Finnish cases, for instance, are based on ad hoc assessment methodologies still under development. Furthermore, only in the case of Buikslooterham is a material flow analysis (MFA) conducted. This well-identified assessment tool is often coupled with CE, but according to Elia et al. (2017), it is not sufficient for validating the pertinence of CE practices, because it does not enable explicitly accounting for all of the environmental impacts. Indeed, MFA is an important territorial knowledge tool, but it does not allow to prioritise and make decisions among the different CE actions. Other tools, such as the LCA, could conversely support such decisions.

In this regard, it is interesting to note that the ‘lifecycle perspective’ seems to be central in all cases, but it is not necessarily associated with lifecycle assessment (LCA) tools. The LCA method seems to be the most complete methodology for assessing environmental impacts and CE requirements (Elia, Gnoni, and Tornese 2017), but nevertheless, in the Kera cases, LCA is planned only at the building scale and for new constructions. The assessment of CE practices is not directly mentioned except in Saint Vincent de Paul. This can lead to contradictions, because as demonstrated during the 63rd discussion forum on LCA²⁶, ‘circularity’ does not always positively affect the environment.

Finally, it is important to note that all these projects are currently underway or were recently started, probably contributing to a lack of precision regarding the performance that will actually be achieved upon delivery.

Conclusions

The literature review reveals a lack of research concerning the application of CE principles to urban projects and their assessment. Accordingly, this paper aims to provide a comparative analysis of four ‘circular neighbourhood’ case studies in order to discuss the CE practices implemented and the assessment tools utilised.

The results of this analysis indicate a large panel of CE practices and a limited use of indicators and assessment tools. Further steps in this research field are required concerning the study and analysis of other cases and tools. Moreover, several authors have highlighted the interest of LCA in evaluating CE (Ghisellini, Ripa, and Ulgiati 2018; Zanni et al. 2018; Elia, Gnoni, and Tornese 2017; Giorgi, Lavagna, and Campioli 2017; Haupt and Zschokke 2017; Fregonara et al. 2017). Two key characteristics of LCA are highlighted by these authors: the ‘life-cycle thinking’, which should also be the basis for EC, and the environmental impact assessment. Thus, the relevance of LCA is also becoming increasingly legitimate to experts, who are beginning to emphasise the importance of LCA to implement EC strategies. In this context, one of the objectives of the PULSE-PARIS project

²⁶ www.lcaforum.ch

involves the concrete application of the LCA method for evaluating the identified CE practices in order to study its relevance and propose possible improvements.

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