Urban Circularity: City Planning Perspectives from the Regeneration of Amsterdam's Buiksloterham District

Georg Hubmann, Theresa Lohse, and Jonas Plenge

Abstract

This article connects city planning with the concept of the Circular Economy (CE). It analyses the case of 'Circular Buiksloterham', one of Amsterdam's post-industrial districts that is transforming into a living example of a Circular City. Firstly, we relate the conceptual background of CE with urban planning and design. Then, we develop an analytical framework for circular urban developments including the following categories: operational implementations, spatial design, social integration and policy integration. In discussions on the interlinkages between circularity and urban planning, we identified and addressed an arguable lack of implementation and little attention for the built environment as gaps in the literature. Based on the case analysis, qualitative interviews and document analyses, we argue that there is an intrinsic link between the organisation of urban resource flows and the production of space. The findings demonstrate that the marriage of circular principles and city planning implies both behavioural adaptations and new technological systems. Furthermore, we identified that making the step up in scale from experimental zones to an entire 'circular district' blurs the holistic nature of CE.

Keywords

Circular economy • Circular city • Resource flows • Urban regeneration • Buiksloterham

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1 Introduction

Urbanisation and climate change are two of the major concerns for city administrations today. Between 1950 and 2000, the global population living in urban areas grew from 30 to 50% and keeps on growing strongly with a prediction of around 68% by 2050 (UN DESA, 2018). At the same time, environmental degradation and the increase of extreme weather events caused by climate change have become key challenges that impact ecosystems, economies and communities around the world (IPCC, 2018; Lehmann et al., 2018; Trenberth et al., 2015). Cities find themselves in a complex dilemma. On the one hand, they are the focal points of development; on the other hand, cities consume up to 80% of total global energy production and account for 71–76% of the world's CO_2 emissions (Hoornweg et al., 2011, pp. 207–211; Marcotullio et al., 2013, p. 622; Satterthwaite, 2008, p. 543). How cities are designed and how they operate significantly affect direct and indirect Greenhouse Gas (GHG) emissions. Especially urban form, infrastructure and supply systems are critical factors because of their strong link to the throughput of materials and energy, waste generation and system efficiencies of a city (Seto et al., 2014, p. 927).

In recent years, the concept of Circular Economy (CE) has gained popularity among urban practitioners, politicians and scholars. CE is seen as a way to help solve cities' complex sustainability challenges by remodelling their urban metabolisms and by applying looping actions to material flows. Yet, there is no clear evidence whether CE initiatives, as they are increasingly implemented by cities and formulated as urban policies, can provide more sustainable results. What is more, the relationship between CE and its biophysical limits including system-wide thinking on entropy and the laws of thermodynamics as well as the altering of materials over time remain unclear (Calisto Friant et al., 2020, p. 4). However, according to the International Resource Panel Report 'Weight of Cities', optimising systems and creating cross-sector synergies between buildings,

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mobility, energy and urban design can reduce GHG emissions and resource use by up to 55 per cent (IRP, 2018). But critical scholarship has pointed to considerable implementation gaps in how such ideas are operationalised in practice (Monstadt & Coutard, 2019, p. 12; Williams, 2019; Williams, 2013), indicating that 'circular urban developments' tend to remain largely on a rhetoric strategy level. At the same time, other authors have noticed a lack of attention for the 'meso-scale' (buildings and built environment) that is between the macro-scale (cities or eco-parks) and micro-scale (manufactured products or construction materials) (Appendino et al., 2019, p. 3; Pomponi & Moncaster, 2017, pp. 3–5). Additionally, the assessment of urban planning strategies in connection with CE are largely missing (Petit-Boix & Leipold, 2018, p. 1276).

Addressing the above-mentioned gaps in the literature, this research analyses the transformation process of Buiksloterham (BSH), an urban neighbourhood in the north of Amsterdam that was launched as the Netherlands' first Living Lab for smart, circular and bio-based urban development in 2015. The two research questions are: How does the notion of CE influence city planning at district scale? How can circularity principles from a Living Lab approach be mainstreamed in urban planning? The purpose of this paper is to take a spatio-temporal perspective during the analysis to investigate the relationship between CE and city planning after 5 years of implementation in the selected case. The goal is to identify levers and barriers of a 'circular urban planning approach' and to give an indication whether the practices of the experimental Living Lab have the potential to be mainstreamed in city planning. Cities are viewed as complex dynamic systems in a continuous state of change, which is reflected in their size, social structures, economic systems, geopolitical settings and the evolution of technology (Kennedy et al., 2007, p. 44). City planning is a way to govern these dynamics with urban planning providing for a spatial structure of activities at city or regional level (Hall & Tewdwr-Jones, 2019, p. 3) and urban design as the process of giving form, shape and character to groups of buildings, to whole neighbourhoods, and to a city, bringing together place-making, environmental stewardship, social equity and economic viability (Raven et al., 2018, p. 142). We argue that there is an intrinsic link between the organisation of urban resource flows and the production of space. Thus, the way resources are managed in a CE does not only effect the urban metabolism but also impact spatial configurations, which are usually under the jurisdiction of spatial planning. Methodologically, this article starts with a qualitative literature review to determine principles of circularity in city planning. Then, an analytical framework is designed that takes into consideration the systemic multi-criteria logic of CE in urban planning. This framework is then used to carry out the analysis by taking a spatio-temporal perspective. In order to monitor the spatial regeneration process of the area, qualitative data was reviewed that is relevant for two points in time; in the case of 'Circular Buiksloterham' the reference years are 2015 and 2020. The empirical analysis relies mainly on three sources: (a) the planning document entitled 'Circular Buiksloterham—Transitioning Amsterdam to a Circular City' (Manifesto),[1] (b) an investment memorandum with the title 'Investeringsnota Buiksloterham 2019' (Ivn.B.2019),[2] and (c) three semi-structured interviews with relevant people involved in the development process that were conducted by the authors between November 2019 and June 2020.[3] The paper is structured as follows: first, we trace the trajectory of the CE concept and link this to urban planning and design. Then, we introduce our analytical framework capable of detecting key features of a 'circular urban development' over time. Next, we apply this framework and present empirical results before we discuss the outcomes and give a conclusion.

2 Principles of Circularity in Urban Planning and Design

The concept of CE and its underlying principles have various conceptual touching points with city planning, understood as both the practices of urban planning and urban design. Despite being multidimensional and transdisciplinary by nature, the common denominator of city planning is its spatial logic. However, there is a tendency to look at innovation processes without reference to the spatial context (Monstadt, 2009, p. 1924). We argue that in the midst of the global resource crisis, there is a gap to close regarding the inclusion of CE in city planning efforts because decisions on urban form and infrastructural systems have long-term consequences and strongly affect a city's capacity to address resilience and sustainability.

[1] This planning document was developed as a vision and ambition document in 2014 and signed by 20 partners in March 2015.

[2] Published in late 2019, this recalibrated version of the 2006 development plan lays out the programmatic, urban planning, environmental, civil engineering and financial framework for the building stock establishment and the land transfer from the municipality to third-party financiers. It is also the development framework for private developers aimed at transforming their own land on their properties or leases.

[3] The first interviewee (Interviewee 1) is a member of the Smart City Amsterdam programme. The second interviewee (Interviewee 2) was a project leader at Waternet from 2014 to 2016. This is Amsterdam's water utility company that was mandated by the municipality with the execution of all water-related tasks in BSH (Gemeente Amsterdam, 2019, p. 73). Interviewee 3 is a representative of Amsterdam's municipality 'Gemeente Amsterdam' working in the team of sustainability advisors for Amsterdam Noord.

A growing number of scholars, politicians and practitioners across different fields are engaging with the concept of CE as an answer to the fossil-based, waste-generating and unsustainable linear economy model (Reike et al., 2018, p. 249; Sillanpää & Ncibi, 2019, p. 26). CE is not new: early thinking on cyclical processes or closing loops dates back to the eighteenth and nineteenth centuries, but integrative waste management approaches, which mark the beginning of the current day discussion of CE, only emerged in the 1970s (Korhonen et al., 2018, p. 545; Murray et al., 2017, pp. 372–373; Reike et al., 2018, p. 248). There are several concepts that laid the way for how CE is perceived today. It is noteworthy that among them are some scholars with a spatial background: the Operating Manual for Spaceship Earth by architect R. Buckminster Fuller (1969), Regenerative Design by landscape architect J. T. Lyle (1970s), and Performance Economy by architect and industrial analyst Stahel (1976) (Ellen MacArthur Foundation, 2013, pp. 30–31; Homrich et al., 2018, p. 527; Sillanpää & Ncibi, 2019, pp. 16–18; Winans et al., 2017, pp. 825–826). Despite its academic origin, contemporary notions of the CE approach have been largely brought forward by practitioners. At the same time, scholarly research is in its infancy and there is substantial conceptual unclarity and fragmentation (Korhonen et al., 2018; Lieder & Rashid, 2016). Blomsma and Brennan who frame CE as an 'umbrella concept' divide its development into three stages, where the latest period starting in 2013 is characterised by a substantial need for theoretical or paradigmatic clarity (Blomsma & Brennan, 2017, pp. 607–610).

The dichotomy between practitioners and academics also unfolds regarding the definition of CE.[4] While a widely cited definition by the Ellen MacArthur Foundation (EMF) has an implicit focus on business models, a more comprehensive definition by van Buren, Demmers, van der Heijden, & Witlox, 2016, p. 3 includes the following dimensions of CE: the 3R framework,[5] waste hierarchies, a systems perspective, environmental quality, economic prosperity and social equity (Kirchherr et al., 2017, p. 228). Using definitions without waste hierarchies might not have adequate impacts on the status quo, e.g. increasing recycling rates instead of initiating a more holistic transformation (Kirchherr et al., 2017, p. 229). Another blurry characteristic of the CE concept is its relationship with sustainable development. While CE is mainly focused on the narrow goal of closing loops giving attention to resource inputs or waste outputs, sustainable development has—similar to city planning—open-ended goals that focus on multiple dimensions surrounding environmental, social, and economic sustainability. Thus, CE is viewed as just a condition for sustainability or a beneficial relation (Geissdoerfer et al., 2017, pp. 762–768). But in the CE literature, there is agreement about missing emphasis on the social dimension while links between environmental and economic issues are pointed out in several publications (Homrich et al., 2018, p. 534; Murray et al., 2017, p. 369; Sauvé et al., 2016, p. 54). Yet, stressing only one or two categories of the sustainability triple bottom line might, for example, lead to a lack of social considerations in implementing CE (Kirchherr et al., 2017, p. 227). It is also unclear how the concept of CE will lead to greater social equality, defined as inter- and intra-generational equity, diversity or equality of social opportunity (Murray et al., 2017, p. 376). The lack of social aspects in the CE concept is thus identified as a conceptual shortcoming that might be problematic for the application to city planning, which fully embraces the three pillars of sustainable development.

There is consensus in the literature about at least three characteristics of CE: (1) the idea of closed loops, (2) decoupling resource use from economic growth and (3) being a radical concept with far-reaching implications for human systems. In general terms, an economy that operates in a circular way should not have negative effects on the environment; rather, the damage done in resource acquisition is restored while as little waste as possible is generated in the production process and during the life of a product (Murray et al., 2017, p. 371). CE enables thinking in cycles and aims at keeping the valuation of materials in closed loops instead of having an open-ended conception of value chains. This can be realised by having an understanding of the relevant 'biological' and 'technical' loops and including at least the notions of input reduction, reuse, and recycling (Bocken et al., 2016, p. 308; Homrich et al., 2018, p. 526; Winans et al., 2017, p. 825). In other words, virgin material or energy inputs to the system and waste as well as emission outputs from the system should be reduced (Korhonen et al., 2018, p. 544). The second common understanding of the CE concept is to allow for natural resource use while reducing pollution or avoiding resource constraints but at the same time sustaining economic growth. CE is widely described as an alternative model of production and consumption as well as a growth strategy that allows for the 'decoupling' of resource use from economic growth, and in doing so, contributing to sustainable development (European Commission, 2020, p. 2; Geissdoerfer et al., 2017; Ghisellini et al., 2016, p. 24). 'Decoupling' means that an economy can grow without increasing the pressure on the environment. Thus, the same economic input is generated based on using less material, energy, water and land resources, while at the same time delinking environmental deterioration. The third

[4] Due to the maximum allowance of words for this publication, there is not enough room for stating the two definitions.

[5] The three Rs mean reduce, reuse and recycle and are part of a framework called waste management hierarchy that indicates an order of preference for action to reduce and manage waste. It is usually presented in the form of a pyramid.

characteristic suggests that a true CE would imply fundamental systemic change including new concepts of systems, economy, value, production and consumption leading to sustainable development of the economy, environment and society (Wu, 2005). However, only 40% of the analysed definitions by Kirchherr et al. conceptualise CE from a holistic systems perspective (Kirchherr et al., 2017, p. 229). In its origins, CE was considered as an approach for waste management but recent notions conceptualise it as "a broader and much more comprehensive look at the design of radically alternative solutions, over the entire life cycle of any process as well as at the interaction between the process and the environment and the economy in which it is embedded (…)" (Ghisellini et al., 2016, p. 12). Thus, CE has the potential to be a model for entirely new living and economic configurations, which overcome business-as-usual resource management.

To conclude, there are various authors who highlight the importance of CE for city planning but further research is necessary to clarify this relationship. Despite the critical importance of land as a source of biomass and energy, for example (Hubacek & Van Den Bergh, 2006, p. 23), and space as interlinked with the main arguments for CE including environmental, economic, social and geostrategic improvements (Van den Berghe & Vos, 2019, p. 2), " [i]t is still unclear how land use can be integrated into CE-related initiatives, design, and evaluation" (Winans et al., 2017, p. 830). However, city planning is considered as a key for moving towards more circular cities because it affects relevant urban strategies such as mobility or construction (Petit-Boix & Leipold, 2018, p. 1279), can provide for the geographical–spatial proximity necessary for industries and businesses to close energy and material loops (Winans et al., 2017, p. 830), and can—through its systemic perspective—promote regulations for stimulating reuse, recovery, repair and the maintenance of existing resources (Girard & Nocca, 2019, p. 34). Agudelo-Vera et al. even argue that some form of urban planning has always been present in the relationship between resource management, urbanisation and technological development (Agudelo-Vera et al., 2011, p. 2302). Still, dealing with resource flows has barely found its way into urban planning literature. Two exceptions are I. McHarg's Design With Nature and M. Mostafavi's Ecological Urbanism. The former aims to protect the values of natural processes and uses matter and cycles as inspiration for sustainable landscape design (McHarg, 1969, p. 55) while the latter argues for overcoming the inherent conflictual conditions between ecology and urbanism (Mostafavi, 2010, p. 3). The premise for bridging resource flows with urban planning and design, however, is an interdisciplinary understanding of the relationships between socio-economic and environmental dynamics and the built environment (Remøy et al., 2019, p. 2).

Recent examples make clear that spatial factors influence the viability of more complex, circular, infrastructural systems, as demonstrated by the district Hammarby Sjöstad in Sweden (Williams, 2013, p. 3) or a case from the Finnish pulp and paper industries (Ghisellini et al., 2016, p. 26). Another example is Saint-Vincent-de-Paul, the transformation of a former hospital in the centre of Paris, which enabled by its strategic location, implemented CE goals, such as the storage and reuse of building components as well as the revitalisation through experimental projects (Appendino et al., 2019, p. 11). In the context of city planning and CE, specific emphasis should be given to the role of people and, in particular, low-income households since mainly a socio-technical approach has been used as of yet (Pomponi & Moncaster, 2017, p. 17). Thus, introducing CE for city planning means to develop areas based on the principle of decentralised, interconnected, polycentric circular urban systems. This requires a re-evaluation of traditional values of the disciplines urban planning and urban design including the scalability of solutions, the approach to infrastructure, the creation of interrelated networks and the role of public space. It would also require an integrated vision and management of the many existing planning tools at the municipal level and appropriate policy instruments (Girard & Nocca, 2019, p. 38; van der Leer et al., 2018, p. 301; Winans et al., 2017, p. 830).

3 Analytical Framework for Circular Urban Developments (AFCUD)

To the knowledge of the authors, there exist at least three evaluation frameworks for CE in urban planning that are designed for specific research goals: the Tetrahedron—a Discourse-Institutional Analytical Framework (Van den Berghe & Vos, 2019, p. 6); the Integrated Evaluation Framework for the Circular City (Girard & Nocca, 2019, p. 41); and the V-H CE Evaluation Framework for Urban Planning (van der Leer et al., 2018, p. 301). These tools make clear that a multi-scale, systemic approach is needed for analysing resource-conscious urban planning. When applied, information can be obtained on the complex interlinkages between transformation processes and resource flows (Voskamp et al., 2018, p. 524). Typically, within CE research there are three key aspects that define different overarching research directions: the technical requirements for closing loops, socio-technical criteria and socio-ecological criteria (Barrera, 2016, pp. 20–24). We enlarge this view by introducing the SETS model that includes social, ecological and technological systems and their dynamic interactions as starting points (Urban Systems Lab, 2020). In addition, the following four multi-scale systemic categories were defined to particularly frame the

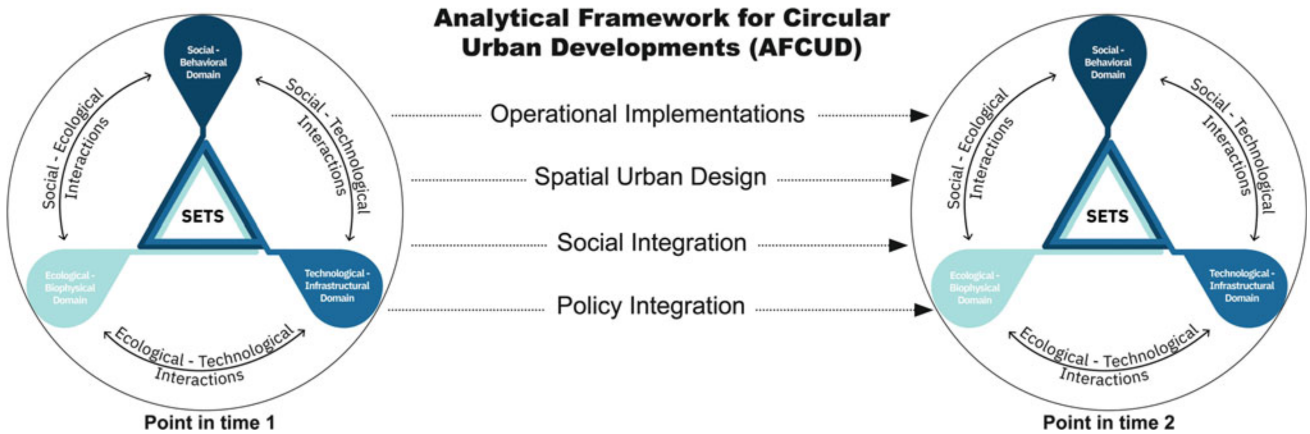


Fig. 1 Analysis of a CE related urban transformation process through the selection of two points in time complemented with four cross-cutting categories

evaluation towards circularity and to be able to focus on the transforming space as well as the political ecology of the processual interactions in reference to the SETS model: operational implementations, spatial urban design, social integration and policy integration (See Fig. 1). 'Operational implementations' refers to the technical requirements for closing loops and the day-to-day components that are relevant in an applied CE. 'Spatial urban design' scrutinises the production of urban space within a given development. 'Social integration' refers to the type of inclusion of local citizens in the redevelopment processes including those who live, work and use the neighbourhood with a specific focus on those who are part of low-income housing schemes. Finally, 'policy integration' is defined as a formalised common set of goals and rules that promote cross-functional communication, collaboration and optimisation that ends ideally in a more or less holistic governance of the systems and subsystems involved.

4 Buiksloterham: Transformation in Progress

The district of BSH is slowly transforming into a revitalised mixed-use area following the ambition to become a fully circular neighbourhood. BSH is a former industrial port area located in the north of Amsterdam with a size of around 100 hectares. In the early twentieth century, it was home to large private productive industries, for example, Fokker Aviation and a waste and power plant that operated until 1993. In the 1980s, the municipality re-examined the area's zones and functions towards a mixed-use residential and working district. In the course of a spatial vision and land development declaration in 1998, the municipality purchased a large share of the industrial property in BSH (Metabolic, 2015, p.86). In 2006, the municipality of Amsterdam took the decision to redevelop the BSH district and published the first version of an investment decision document for the area. As a consequence of the financial crisis and the lack of commercial real estate development interest, the municipality launched a call for tender for the former DeCeuvel shipyard in 2010 (Gladek, et al., 2014, p. 90). Targeted were creative and sustainable proposals for a self-build temporary use. Following the well-received winning proposition for a contaminated soil regeneration through phytoremediation vegetation, the municipality articulated their interest in a vision for 'Circular Buiksloterham'. The planning framework for a circular district was then developed in 2014 as a collaboration between the municipality (Gemeente Amsterdam), an urban design and architecture office, academics as well as urban and cultural organisations (Table 1). The project was termed 'Living Lab Plan' with the underlying idea that individuals, households, collectives and private businesses build their own homes side by side—driven by the fundamental idea of closing urban material cycles (van Bueren & Steen, 2017, p. 18). The following sections focus on the recent transformation of the district and will evaluate the urban regeneration of the district between two points in time (2015, 2020) and along the defined categories in the analytical framework considering social, ecological and technological perspectives.

4.1 Operational Implementations

Material Use: As key circular operation, building materials and their recycling methods are envisioned to be closed loops in the new building developments of the district. The Manifesto states an ambition of nearly 100% material recovery and reuse for any new builds in the area of BSH and demands a material passport "to record material properties and origin" (Metabolic, 2015). These two ambitions are readopted in the Ivn.B.2019 but the building material reuse is further specified for 50% recycled materials and 30% renewable materials; and 80% of both in public space interventions. One of the first successful implementations of recycled materials was completed in the mobility hub space of the 'Schoonschip' scheme by using recycled baked bricks (Gemeente Amsterdam, 2019, p. 68).

Waste: To enhance a full waste recycling plan at urban scale, the overall strategy targets the apartment level and user-behaviour as well as the overall district level. Different strategies were envisaged for further development in both source documents. As for the Manifesto, waste separation is laid out for buildings and public spaces with source separation via a colour-coded bin system, containers on ground floors, and through vacuum systems that transport waste underground to a central facility (Metabolic, 2015). An explicit technical proposal for waste recycling at the user end is a sink drainage macerator that grinds food and organic waste in apartment kitchens. The biomass is centrally collected and used for green energy generation. In the recent Ivn.B.2019, these two strategies are detailed resulting in a waste separation agenda based on six waste fractions for both commercial and residential. The collection will be underground and laid out for efficient use of space at district level, e.g. keeping short distances between the end user and container locations. This solution, which is proposed by the municipality, is only assigned for households, yet larger companies need to directly contract waste disposal businesses that implicate longer hauls (Interviewee 3, personal communication, June 5, 2020).

Water: the analysis of all three sources made clear that the technical circular objectives concerning water management mostly proceeded to a successful implementation at a small to medium scale. The Manifesto plots two primary aims: first, natural water management and the smart use of water and second, efficient treatment of wastewater for nutrient recovery and micropollutant removal (Metabolic, 2015). This results in the definition of separate urine collection, water saving measures, rain water collection and natural water buffering, resource recovery and entire micropollutant removal (Metabolic, 2015). The companies Waternet and DeAlliante started to realise a black and grey water separation system for about 100 households in the course of the Living Lab project of 'Schoonschip' (See Fig. 2). In this system, a neighbourhood biorefinery recovers minerals from grey water that can be reused as fertiliser and biogas is produced from the black water that is further used as energy. The black water is collected from the toilets through a vacuum sewer system (Interviewee 1 & 2, personal communication, November 6, 2019). Alongside heat generation from grey water recovery, the Ivn.B.2019 suggests vacuum sewage and wastewater separation for three plots with over 600 dwellings including 'Schoonschip' and optionally some connections to large mixed-use plots (Gemeente Amsterdam, 2019). In practice, the vacuum toilet flush and its increased noise level was received divergently throughout the resident groups. The acceptance in social housing properties is very low compared to the free market properties and Living Lab projects (Interviewee 3, personal communication, June 5, 2020).

Energy: With respect to energy-related strategies, it is a general goal of the City of Amsterdam to reduce CO_2 emissions by 55% until 2030 compared to 1990 and to become fully supplied with renewables by 2050. The primary approach for this goal is the production of local energy—ideally directly on the plots. In the Ivn.B.2019, it is stated that this is obligatory for all energy except district heating. The following strategies for this goal's accomplishment are proposed for private land: (a) using roof and façade areas to generate electricity through photovoltaics and (b) using surface water for cooling and/or regeneration. For public space, the goal is to become energy-neutral and provide sustainable energy from solar panels (Gemeente Amsterdam, 2019). In

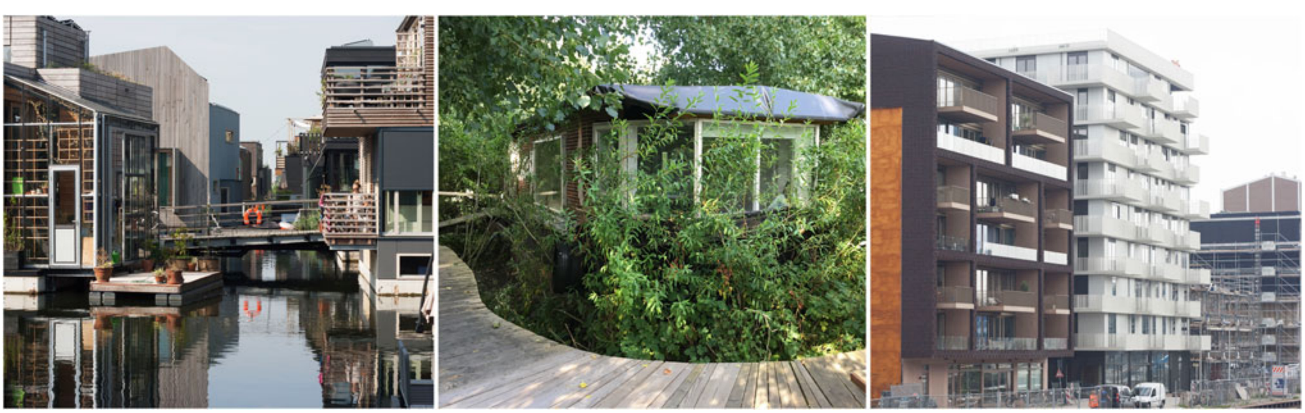


Fig. 2 Different housing projects in Buiksloterham: floating architecture of the Schoonschip project (left), elevated walkways and reused boats of DeCeuvel (centre) and the beginnings of the Cityplot project (right). *Sources* author's own

comparison, the Manifesto constitutes an estimated energy supply decline of 60% financed by the Circular Investment Fund and maps out pilots for a parallel AC/DC smart grid (Metabolic, 2015). Selected were the two Living Lab projects 'DeCeuvel' and 'Schoonschip' (See Fig. 2) that are equipped with a smart grid and are envisioned to be scaled via tenders on municipal, leasehold or private plots in BSH, as indicated in the investment memorandum. 'DeCeuvel' established an energy token for all locally generated renewable energy, which is tracked in a blockchain and a money token to trade the produced energy with local goods in the community (Metabolic, 2018, p. 1). Following in the footsteps of 'DeCeuvel' and 'Schoonschip', two additional plots will implement a smart grid in the upcoming years and establish a local energy market for residents. This way, users will be able to trade energy that can not be used sustainably by themselves (Gemeente Amsterdam, 2019).

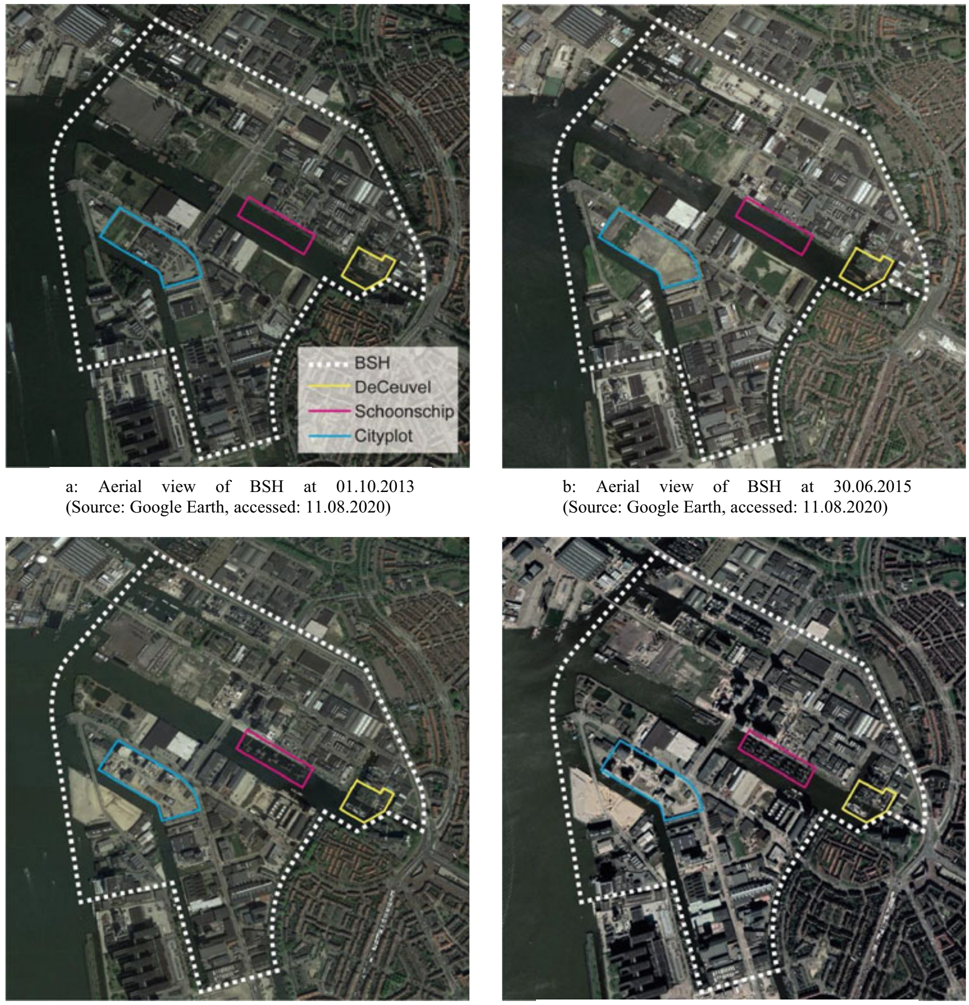
4.2 Social Integration

As part of the assessment in preparation for the Manifesto in 2014, stakeholder analyses and interviews were conducted to assign interested parties to engagement groups. The most significant declaration hereof states: "it is impossible to create any kind of meaningful or lasting change without broadly engaging the parties within a particular context who either: (1) have decision making power or (2) are subject to the results of decisions made" (Metabolic, 2015). The project coordinator Metabolic and Stadslab (local communication platform) held stakeholder meetings at regular intervals, especially with residents. A member intensively involved in these meetings, however, strikingly expressed that the participants' attention and willingness to invest time was most challenging during the process but, over time, resident groups were increasingly taking part in participation formats. Yet, there is a tendency that people with a 'green living mindset' have been moving to BSH (Interviewee 1, personal communication, November 6, 2019). In contrast, residents of the social housing schemes who were assigned to a home in the area and did not specifically apply for living there are generally less engaged in the circular neighbourhood development. A simple formula for the future of social integration to develop an urban circular economy was voiced by one interviewee: "In the end, it's not about what we have achieved so far, it's about making circular thinking mainstream" (Interviewee 1, personal communication, November 6, 2019). The Manifesto set out a Neighbourhood Action Plan as an active participation method that translates high-level goals into everyday actions (Metabolic, 2015). This was introduced together with an award economy on community and Living Lab level where people can trade their self-building and other skills in exchange for money (Metabolic, 2015).

In preparation for the recent investment memorandum, the municipality (Gemeente Amsterdam) hosted several stakeholder meetings during which the details of the area development were left aside but instead the focus was on participatory instruments and developing common visions. Additionally, walk-in evenings with the purpose of relationship management between residents, entrepreneurs and developing parties were held monthly with most questions forwarded to the municipality (Gemeente Amsterdam, 2019). Nonetheless, the investment document records that public participation will only be administered by the municipality for public space with exact topics defined for wilful engagement. For instance, this includes existing road refurbishment as well as park, playground and sport facility design (Gemeente Amsterdam, 2019). For all other plots, the level and method of participation needs to be proposed by the developer who applies for a building permit. Overall, the envisioned participation is based on a new policy framework called 'Democratisation' that frames Amsterdam's principles and action streams with regard to increasing the control and ownership of residents over their neighbourhood. It is the goal to decide up front which instrument of participation will be chosen and the intention is to clearly communicate when, why and which form of cooperation is intended (Gemeente Amsterdam, 2019).

4.3 Urban Spatial Design

For the development of BSH, a mixed working and living structure at district level is foreseen. In contrast to the Manifesto, where an equal distribution between production and living was proclaimed (Metabolic, 2015), a minimum of 20% of the programme is reserved for business activities and a maximum of 70% for housing according to the Ivn.B.2019 (Gemeente Amsterdam, 2019). This shift might indicate the great pressure on the housing market Amsterdam is currently experiencing. According to the municipality of Amsterdam, a productive city district contributes to circularity in the way that production and consumption flows are allocated closer to each other (Gemeente Amsterdam, 2019). The programmatic mixture gives rise to the need for flexible and adaptive buildings that can react to programmatic change. Therefore, rules for the development of building plots were introduced (Gemeente Amsterdam, 2019). Also, special zones for the experimental development of new building typologies were declared (Gemeente Amsterdam, 2019). The aerial views depicted in Fig. 3 clearly reveal the development progress of the two mentioned experimental zones 'DeCeuvel' and 'Schoonschip' over recent years. Furthermore, development and construction on the site of the 'Cityplot' has started. After the experimental zones, this is the first larger scale area



a: Aerial view of BSH at 01.10.2013 (Source: Google Earth, accessed: 11.08.2020)

b: Aerial view of BSH at 30.06.2015 (Source: Google Earth, accessed: 11.08.2020)

c: Aerial view of BSH at 20.04.2019 (Source: Google Earth, accessed: 11.08.2020)

d: Aerial view of BSH at 21.03.2020 (Source: Google Earth, accessed: 11.08.2020)

Fig. 3 Aerial views of BSH at different points in time indicating the progress of development

that is supposed to be developed following the guidelines of the Inv.B.2019.

Mobility: One of the operational fields that to a large extent interferes with aspects of spatial and urban design is mobility. The Manifesto demands zero-emission mobility in the area of BSH by reducing the overall mobility and considering concepts such as shared mobility and mobility hubs with the opportunity to host innovative modes of transport as well as elevated bike and pedestrian paths (Metabolic, 2015, p. 32, 39,164). Importance is given to the integration of the waterways (River IJ, Johan van Hasseltkanaal) as a hub not only for passenger transport but also for any other kind of infrastructural connection and logistics (Gemeente Amsterdam, 2019; Metabolic, 2015). Resembling partly the proposal in the Manifesto, the Ivn.B.2019 sets a general plan of parallel roads and canals that give access to the plots, which—depending on their depth—are interconnected by informal green pathways. Most of the plots allow public access to the waterfront (Gemeente Amsterdam, 2019). It can be seen as a spatial decision to ensure water accessibility for a later implementation of technical interventions that interact with water areas (Gemeente Amsterdam, 2019). As for circular mobility, the Ivn.B.2019 plans a bicycle network embedded at city scale, the encouragement of subsystems for (electric) cars, and a combination of bicycle and car parking. Restrictions for motorised through-traffic are additionally planned to reduce any further emissions (Gemeente Amsterdam, 2019). The ambition to establish an integrated mobility system was mentioned as one of two successfully started projects touching on the circular planning mindset. (Interviewee 1, personal communication, November 6, 2019).

Green Areas: Another aspect that affects both spatial planning and the circular constitution of a city district is the realisation of green areas and vegetation. According to the vision of 2015, street vegetation should increase ecological and economic value and urban greenery is intended to relieve local sewage systems (Metabolic, 2015). Spatially disconnected and inaccessible green areas are supposed to be integrated into the city structure (Metabolic, 2015). The current zoning plan reacts to these requirements. The vision of having a “green neighbourhood bustling with activity” (Metabolic, 2015) is continued in the Ivn.B.2019. At district level, at least 22 m wide green corridors are placed to connect canals and streets to guarantee the buffering of water and heat (Gemeente Amsterdam, 2019). Additionally, river and canal banks will be reserved for greenery and public parks (Gemeente Amsterdam, 2019). At plot scale, greenery is to be included and integrated and will be part of tender negotiations. Especially on deep parcels, green courtyards are essential to support circular goals of rainwater reuse and increased biodiversity.

4.4 Policy Integration

The intention of establishing a circular city district requires a stable policy framework that exceeds the given laws without losing its original intention (Metabolic, 2015). The Manifesto lays out a policy regarding the Living Lab idea, executed, e.g. in projects like ‘DeCeuvel’ and ‘Schoonschip’ (See Fig. 2) in form of a ‘Neighbourhood Action Plan’. This required, among others, the declaration of ‘special physical zones’ for urban experiments in order to be able to continuously experiment within the given laws (Metabolic, 2015). Furthermore, detailed guidelines for housing developers concerning energy demand and the choice of building materials are postulated (Metabolic, 2015). The Manifesto proposes loosening restrictions in current laws to make an integration of technical interventions feasible, for example, the reuse of grey water (Metabolic, 2015). In practice, the process of adapting the circular approach to current rules is depicted by an involved planner. He describes the encounter of barriers set by legislation as a habitual thing when accessing a new innovative idea. However, translating solutions into existing legislation settings often turned out to be a tiring and time-consuming process (Interviewee 2, personal communication, November 14, 2019). By signing the Manifesto in 2015, the municipality declared the ‘Circular Buiksloterham’ approach an inherent part of all future developments in the area (Gemeente Amsterdam, 2019). To emphasise that the ambitions displayed in the Manifesto of 2015 will be complied with, the essential points are partly translated into a set of ‘circular rules’, valid from 2019 onwards. But the municipality aims at a different level of policy integration due to its impetus of setting a framework for developing an entire city district rather than only focusing on experimental Living Labs. Circular rules are applied at two levels: firstly, the so-called ‘starting points’ are defined as minimum requirements to be met; secondly, ‘ambitions’ can be discussed within the tendering process of a new development project (Gemeente Amsterdam, 2019). According to a representative of the municipality, the mentioned framework for BSH has higher ambitions towards circularity than other districts. The level of innovation included in the circular urban development idea and formalised in both the Manifesto and Ivn.B.2019 is a requirement when approaching a new development (Interviewee 3, personal communication, June 5, 2020). Negotiations are conducted with and are depending on the influence of the sustainability advisor responsible for the area (Interviewee 3, personal communication, June 5, 2020). The suggested special physical zones can be re-encountered in the spatial programme proposed by the municipality that foresees experimental forms of housing as well as the experimental development of production (Gemeente Amsterdam, 2019). Exemplary is the approval of the ‘Schoonschip’ project through an amendment plan. By making use of the option of deviation offered in the zoning plan, an agreement could be made and innovative ideas were realised (Gemeente Amsterdam, 2019). The set of rules described as circular mainly focuses on the implementation of circular aspects at an operational level, comparable to the guidelines for (housing) developers and the technical interventions in the Manifesto.

5 Discussion

In this article, we analysed the urban regeneration of ‘Circular Buiksloterham’ with a spatio-temporal approach taking into account a time span of 5 years to understand more closely how the concept of CE is interrelated with city planning. First of all, the city of Amsterdam is a key driver in pushing the development of BSH towards a resource conscious neighbourhood. This can be noticed, for example, in more ambitious regulations than in other districts, the financial commitment and the establishment of ‘special physical zones’ for experimentation with existing laws. Additionally, the aerial images show a certain level of progress regarding the implementation. Besides greenery for climatic functions and recovery strategies for operational elements (energy, water and materials), aspects of circularity were also considered in the spatial design of the district. All the plots have proximity to the water and to the streets for the potential implementation of technical interventions (e.g. traffic or recycling infrastructure) and waste hubs were installed at an early stage. Thus, by considering the results of the analysis and against doubts from the literature review, a circular urban development is taking place. The proposed and partly implemented solutions in BSH go beyond the rhetorical level and the spatial dimension is included in the innovation process. However, it is interesting to see that the target for the share of housing in the area increased from 50 to 70% during the observed period between 2015 and 2020, whereas the production/business share declined from 50% to a minimum of 20%. This might be connected with the city-wide economic pressure to build more social housing and opens up simple technical questions for a 'full circularity'. For example, will it be possible to generate enough electricity or heat on-site with a significantly lower amount of industry in the area? Another striking aspect is the introduction of starting points and optional ambitions for developers. For example, in terms of material use this means that all the timber used for construction must comply with forest management standards but the application of 50% recycled materials and 30% renewable materials is optional. This might be another drawback for realising the ambition of a fully circular neighbourhood. Given these points, our general impression is that 'Circular Buiksloterham' is at a stage where it is scaling from small Living Lab zones to larger developments such as 'Cityplot' with 550 dwellings (See Fig. 2), and eventually to the entire district. This seems to result in a relaxation of the requirements and in a new development logic that is no longer targeted at specific user groups but instead entails planning for a more general public while at the same time answering to economic pressures.

The modifications made at the planning level over time suggest a less holistic implementation of CE principles than originally proposed. Yet, conceptually speaking, there is agreement in the literature that CE is a radical concept with far-reaching implications for human systems. When the Manifesto was published, a holistic approach was proposed including reward schemes and rules for social behaviour. The IncB.2019's ambition and view on circularity follow the Manifesto but the definition of the actual rules reveal trade-offs. At this point, the nature of the CE approach shifts to a rather operational, technically driven concept. Although the renewable energy reward system established at 'DeCeuvel' shows that under 'urban laboratory conditions' a closed regenerative system can lead to a strong alternative. In fact, urban experiments on a small scale can be successfully operated and legislative hurdles can be cleared but the development process is time and energy consuming (Interviewee 2, personal communication, November 19, 2019). And since the next step of the development is to scale up the size of plots and the number of inhabitants in order to address the housing shortage, a transition of the good practices collected at the Living Labs seems to fall flat. Thus, due to the scale of implementation, the more radical theoretical notion of CE including behaviour and system changes conflicts with the new plan for Buiksloterham that is predominantly relying on technical and operational solutions (See Appendix).

Taking a closer look at the social dimension reveals that the suggestions in the literature review about missing emphasis on social considerations while implementing CE-related urban functions are reasonable. In the case of Buiksloterham, the two pioneer projects 'DeCeuvel' and 'Schoonschip' (See Fig. 2) show that the idea of Urban Circularity attracts 'avantgarde' thinkers who constitute a small section of society (Interviewee 3, personal communication, June 5, 2020). In general, the target group of the two Living Lab projects were young, well-educated people including entrepreneurs who contributed with their own ideas about the design of the buildings via a participation process. Sharing the same convictions and beliefs around closing loops makes them invest time, money and energy, taking into account the barriers and associated frustrations (Interviewee 2, personal communication, November 14, 2019). Thus, it is of great importance to address the question of social acceptance for new systemic solutions that include technical artefacts that are not trivial but necessary due to the requirements of circularity. This is exemplified by the introduction of a vacuum toilet system, which is a component of a loop-closing technical intervention. The increased noise levels, the somewhat unusual design of the toilets and the strict guidelines for what to put into this system were not well received by social housing tenants while it was successfully tested in the experimental environment at 'DeCeuvel'. Thus, new systems that are necessary or planned in order to close loops at neighbourhood scale need to be clearly articulated and widely tested in order to raise acceptance for the required changes. Otherwise, this can lead to refusal among future residents because the acceptance of a new technology or a change in behaviour is not scaleable but instead requires a step-by-step adaptation process.

Lastly, the proposed analytical framework (AFCUD) was useful to structure the research process and to generate conclusions regarding the relationship between CE and city planning. Interestingly, as also the reviewed literature demonstrates, the ecological perspective was weakly covered during our analysis. This was first and foremost due to the lack of data, however analysing Urban Circularity from an ecological perspective holds potential for future research.

6 Conclusion

The case of 'Circular Buiksloterham' indicates a strong relationship between CE and city planning. It became clear that the central component of city planning, its spatial logic, is coupled with resource-oriented fields such as energy, water, waste and materials. These are important for establishing a CE while every systemic intervention within those fields generates spatial conditions and dependencies. The development rules of BSH clearly include ideas that are derived from resource management and the notion of circularity is indeed part of all the analysed research categories. At the same time, there are two well established Living Labs that have been implemented in recent years taking into consideration circularity measures on both construction and behavioural levels. But making the step from those experimental zones to an entire ‘circular district’ was identified as the key challenge in Buiksloterham. Many prerequisites, such as a joined-up regulatory framework as well as technical and political levers, are in place but there is increasing economic pressure to build affordable housing and the institutional capacity for scaling up the Living Labs including lengthy coordination processes is lacking. Instead, the guiding principles were relaxed to make way for large-scale housing developments—maybe still more ambitious regarding circularity than other projects but no longer following the holistic idea of CE. Scaling up as the next step in the development process also reveals a double social problem when combining principles of CE and city planning at district scale. On the one hand, there is a need to accept new technological solutions necessary for Urban Circularity and on the other hand, the appropriation of a new reality is necessary that includes the adaptation of behaviour and an openness for cultural change. With this research, we addressed two research questions. How the ideas of CE impact city planning at neighbourhood scale was answered throughout the paper with the example of BSH. Whether the Living Lab approach of ‘Circular Buiksloterham’ can be mainstreamed in city planning is more difficult to answer. Our opinion is that there is a lot of potential in the areas of energy, waste, water reuse, biodiversity and ecosystem services but the case of BSH showed that the closer the realisation of a ‘fully circular neighbourhood’ is, the less radical the proposed solutions will be. Further research is necessary to address the ‘problem of scale’ within the idea of Urban Circularity and if and how the marriage of circularity and urban planning contributes to environmental goals such as climate-neutrality.

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Appendix

See Table 1.

Table 1 Circular rules (Aadapted from Gemeente Amsterdam, 2019, p. 79)

Subject (Definition)	Rules
General	**Starting Points** The developer subscribes to the circular ambitions letter of BSH and takes the included principles and rules into account during the plot development
Sustainable Mobility Mobility that contributes to a clean, safe and accessible neighbourhood	**Starting Points** – Sufficient space for parking bikes – At least 25% of the parking spaces in parking facilities should be equipped with electric charging points. Prepare the remaining 75% of parking spaces for electric recharging by using sheathing tubes and cable ducts. A checklist is available on request – Smart and sustainable construction logistics **Ambitions** – Application of subsystem for (electric) (container) bicycles or (electric) cars on the plot – Linking local sustainable energy generation to energy storage in electric cars
Energy The energetic quality of the programme and its functions	**Starting Points** Energy-neutral or energy-generating new building with an EPC $\leq$ 0,00 (in accordance with NEN 7120) – When determining the EPC, renewable energy is generated on location/plot (with the exception of district heat and cold) – The application of the EMG (NEN 7125)—sustainable energy generation remotely—is excluded – Renewable energy generation on location must be incorporated into the architectural design **Ambitions** – Application of smart grid system on the plot, possibly linked to electric cars charging points. The various systems will be headed towards a smart grid at district level

(continued)

Table 1 (continued)

Subject (Definition)	Rules
Durable heat and cold supply The way in which the programme is provided with space heating, hot tap water and cold supply	**Starting Points** – A connection to natural gas is not possible – There is an obligation to connect to the municipal grid 'Westpoort heat network' – The developer/initiator can create an exemption or apply for exemption from the connection obligation if the development is sufficiently sustainable – The application of conventional cooling or heating systems is not a problem – Boilers, electric boilers or conventional cooling machines are not allowed
Commodities and materials The application of raw materials and materials on the development plot	**Starting Points** – The development has an MPG $\leq$ 0.5 (excluding input PV panels) – All the timber used must demonstrably comply with the principles of sustainable forest management (FSC label or equivalent) – Application of material passport **Ambitions** – Apply 50% recycled material – and 30% use of renewable materials
Waste collection The way household waste is collected	**Starting Points** – Facilitate separate waste collection on the plot—in at least the following six fractions: glass, paper, PMD (plastic/tin/metal/beverage cartons), textiles, GFE (vegetable, fruit and vegetable/food waste) and residual waste
Green and Biodiversity The amount of green space, the quality of green spaces	**Starting Points** – Within a development unit, an area that is comparable to at least 40% of the surface area of the development unit should consist of greenery. This includes green roofs, green skins or greening of the ground level that is not built on. For the roof, a minimum substrate thickness of 10 cm is required – Biodiversity: minimum application of three measures from the nature-inclusive building manual
Water: Rainproof and reusing water The way in which measures are taken at plot level that contribute to climate mitigation and water reuse	**Starting Points** – The minimum water storage on the lot is the total lot area x 60 mm – 60 mm precipitation (=60 L per sqm) is retained for more than 24 h – The water is drained off with a maximum rate of 2.5 L/sqm/hour – Collected rainwater collected should be reused for the irrigation of green spaces on the plot **Ambitions** – Rainproof for 90 mm precipitation – Reuse of water for toilet flushing or possible other functions
Flexible and future-oriented buildings	**Starting point** – Separation of carrier and installation is mandatory for a flexible building layout that possibly can change in the future

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