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Shifting circular: urban infrastructure and policy changes towards renewed territorial metabolisms

Hugo d'Assenza-David

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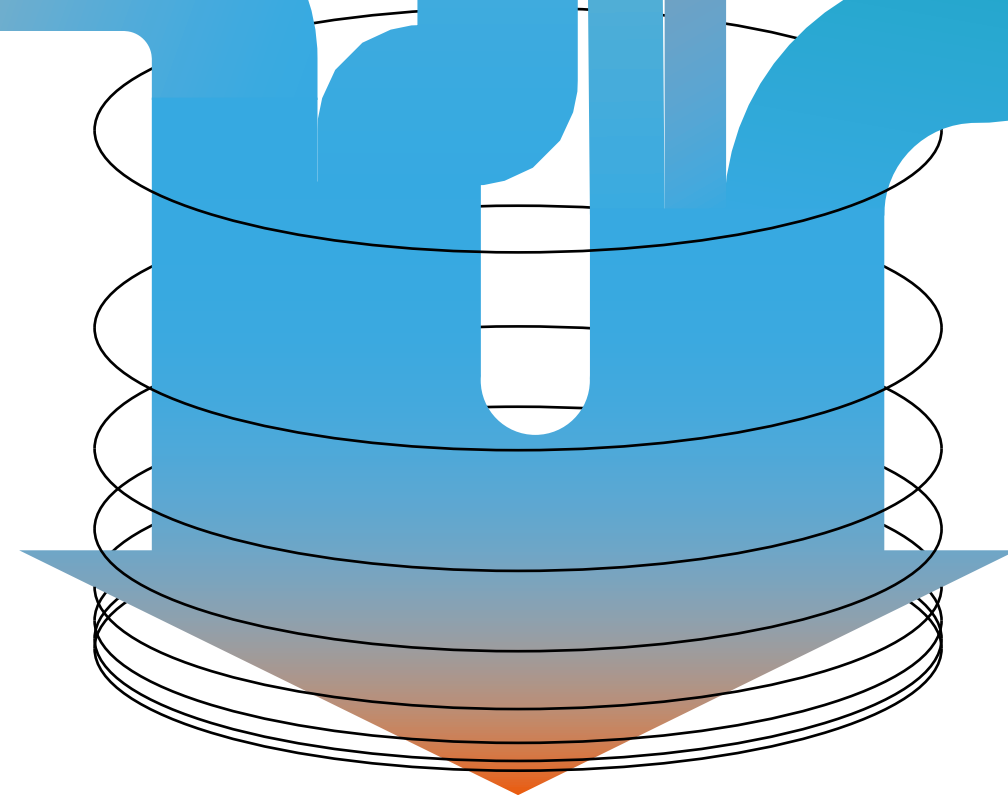


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Shifting circular:

urban infrastructure and policy
changes towards renewed
territorial metabolisms



*A comparative analysis of the Paris,
Hamburg, Amsterdam and Brussels
metropolises*

Context of the report

In 2021, the G20 acknowledged the need to accelerate resource efficiency and the role of cities and local governments in this perspective. The Think20 (T20) also recommended moving towards a G20 pact on sustainable urbanisation. In 2022, following two cycles on 'plastics' and on 'value and supply chains', the third cycle of the Circular Economy Solutions Dialogue (CESD) focused on 'Localising the circular economy imperative – What is at stake for cities?'. During these sessions, experts were invited to exchange perspectives and solutions to reach circularity at different levels. Following these cycles, this report has been commissioned by the GIZ global project supporting the "Export Initiative Environmental Protection", which contributes to solving key environmental problems on behalf of the German Federal Ministry for the Environment and Consumer Protection (BMUV).

Hugo d'Assenza-David wrote this contribution between July and November as a freelance researcher. This work, based on his previous research on Brussels and Amsterdam, is a comparison between these two metropolises, Paris, and Hamburg. In this research, he describes, characterises and compares policy and planning initiatives to promote the circular transition from the experience of key stakeholders operating in these four European metropolitan contexts. This research aims at identifying and putting into perspective some of the physical, institutional, legal, or economic infrastructures conducive for the development of the circular economy in urban contexts. Specific attention is paid to material flows and sectors with a high circular potential in metropolitan areas. This study ultimately proposes a reflection on issues, drivers, good practices, and remaining gaps to trigger a circular economy. From the experience of European metropolitan contexts, this piece of work aims at inspiring stakeholders concerned with urban transition issues in a global perspective. In the end of the report, a few inspiring initiatives are presented in more depth.

Summary

administrative silos, but also to compensate for the limits of the market and include biophysical considerations in the assessment of economic performance. Moreover, the need for new nexus infrastructures, may these be physical or not, is also an invitation for public governments to redefine their interventionist role and act as transition broker.

Then, the development of innovative policies and infrastructures in line with circular objectives paves the way for new subtle interactions between bottom-up and top-down approaches. While this is about triggering symbioses between stakeholders that, until now, barely talk to each other, it is also about operating in a multilevel governance scheme, in which localities may play a pivotal role at the intersection between holistic thinking and concrete developments and benefits.

Overall, shifting circular is not only about a biophysical rationalisation of material flows: this is a whole societal project that includes behavioural patterns and requires new policies, regulations and interventions to concretise this yet envisioned future. It is also at the core of a paradigm shift that must be collectively defined to modernise our economy and make it fit in the 21st century challenges. A preliminary question that needs to be asked is our definition of prosperity: how do we conceive collective thrive in a resource finite world? As this report suggests, cities, as scouts of a world in transition, can provide us with important elements of an answer.

The Circular Economy highlights the need to re-design infrastructures and policies in line with biophysical needs and constraints. Shifting circular is then an imperative, a multilevel challenge that requires targeted innovation. While this envisioned future is on everyone's lips, putting forward a new sustainable horizon, the path remains to be settled. How to start and scale-up circular initiatives? Who are the game changers? What infrastructures and policies are needed?

From a crossed analysis of four European metropolises and based on the insights of more than 40 experts from various sectors and institutions, we have highlighted common trends, innovative initiatives and challenges to trigger the circular transition. Lessons drawn from the fields studied are generalisable and might be a source of inspiration for other urban contexts, in Europe and beyond.

In this report, we highlight the potential of betting on the local and urban scale and conceiving these socio-ecological transformations from a territorial metabolic perspective. How would a way forward to a circular city look like? Three of its aspects are successively put forward: while urban areas are hubs for biophysical material flows, these are also physically constrained spaces in which different functions cohabit, and a contextualised local scale of governance. Each of them was then put into perspective with the implications of the circular transition.

Key lessons were drawn. It first appears that public governments have a central role to play to trigger holistic thinking, to enable a coordinated action beyond sectorial and

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Head of Project

Markus Luecke
Köthener Str. 2
10963 Berlin / Germany
T +49 30 338 424 646
E markus.luecke@giz.de

Responsible for implementation

Dr. Holger Kuhle
Köthener Str. 2
10963 Berlin / Germany
T+49 30 338424 456
E holger.kuhle@giz.de

Author

Hugo d’Assenza-David
Institut d’études politiques de Paris – Sciences Po
E hugo.dassenzadavid@sciencespo.fr

More information

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Edited by

Dr. Holger Kuhle
Katharina Lange

Design

MUS
Glogauer Straße 6
10999 Berlin / Germany
T +49 30 120 53 600
E hello@mus.studio

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List of Abbreviations

BUKEA	Hamburg Authority for the Environment, Climate, Energy and Agriculture
CEBIZ	Circular Economy Business Innovation Zone
CIRCulT	Circular Construction in Regenerative Cities
G20	Group of Twenty
MFA	Material Flow Analysis
MOOC	Massive Open Online Course
NGO	Non-Governmental Organisation
NUTS	Nomenclature of Territorial Units for Statistics
PREC	Circular Economy Regional Plan
PUMA	Prospecting the Urban Mines of Amsterdam (PUMA)
SME	Small and Medium-Sized Enterprise
TACT	The Air Cargo Tariff and Rules
ZEMU	Enterprise Zone in Urban Areas (Zones d'Entreprises en Milieu Urbain, ZEMU)

Introduction

developed to trigger local circular transitions. These refer to governance mechanisms, institutional design innovations, or initiatives in favour of circular ecosystem synergies. Similarly, policies and institutions aiming at favouring localised knowledge-creation are no less important to envision a local governance of material flows.

Along this report, we argue that the circular transition requires the development of new physical, social and institutional infrastructures. While an overwhelming majority of bio-physical circuits are linear, these new developments must be understood as enablers, levers and beachheads towards circular material flows. These may indeed impulse new dynamics, incrementally modifying the rules, incentivising markets and stakeholders to take the plunge. These infrastructures embody a great opportunity for public governments to redefine their role and shoulder new responsibilities as transition brokers. Through a targeted action, including expenditures, architectural practices and incentives, urban planning development or governance features, public authorities may provide the can opener to unleash the potential of the circular economy Pandora's box.

By taking on new strategic missions in line with transition objectives, government interventions could redefine public-private economic relationships in socio-economic regimes and favour the reorientation of the whole landscape.

Our reflection leans on a compared analysis of four European metropolises, Paris, Amsterdam, Hamburg, and Brussels. Despite their distinct trajectories, these are economic locomotives sharing similar challenges regarding the sustainability of their model of development, now based on externalised supply chains and productive apparatuses. These also host major trade infrastructures, like ports, whose business model may be modified to play an adjuvant role in the circularisation of the economy. To write this report, interviews, secondary literature and policy document analysis as well as academic literature review were mobilised. While some data and testimonies were gathered from previous research works Hugo d'Assenza-David carried out in Brussels and Amsterdam, most of the information for the Paris and Hamburg metropolises were gathered between July and October 2022.

For the study, we focus on these European metropolises. The Circular Economy has indeed been put forward as one of the key priorities for the European Union, and the cornerstone of the European *Green New Deal*, adopted in 2019. More recently, the *Leipzig Charter* reinforced cities as locomotives for the ecological transition by both an increased attention paid to sustainable measures and the related development

From the second part of the 2010s, various kinds of initiatives attempting to circularise material flows flourished within cities and seem worth looking at and comparing. What is their trajectory? What needs do these fulfil? What are their limits? Despite this increasing attention, circular initiatives still marginally modify the way urban metabolism works. Then, a particular attention should be paid to the challenges ahead to trigger their scaling up. Besides that, resources to be processed are subject to specific constraints and properties: circularising these requires a consideration of the interactions between public institutions, economic stakeholders, or other civil society partners. Critically assessing local initiatives, highlighting their transformative potential, and identifying how gaps could be addressed then appears central to envision how the circular imperative could materialise in connection with urban fabrics. Solutions developed to achieve circular goals must be context-based. Developing such a knowledge is key to envisioning circular policy and infrastructure developments in favour of the ecological transition. In this study, we aim at mapping and reflecting on these required changes for the development of a circular economy in cities. On the one hand, this consists in highlighting the direct infrastructures required for a circular transition, physical and measurable adjuvants mobilised to directly influence start-up and scale-up transitioning dynamics. These include architectural or urban planning considerations, but also financial mechanisms and public subsidies allocated to trigger certain forms of economic development in line with the circular imperative. Regulations could also be considered as such. On the other hand, the reflection also focuses on more indirect components, including non-binding, incentivising and indirect measures

of productive infrastructures. ‘Small-scale businesses, low-emission-manufacturing and urban agriculture’ are then presented as key drivers for the re-integration of ‘production into cities and urban areas, enabling and promoting new forms of mixed-use neighbourhoods’ (European Commission, p.6).

‘Some European frontrunner cities can already provide a blueprint for a net-zero carbon city today. The transformation requires investments in innovative and efficient technologies as well as fundamental changes to production and consumption, allowing for the establishment of a circular economy which redefines and ensures a sustainable use of resources, while significantly reducing waste and carbon emissions’

The New Leipzig Charter (European Commission, 2020)

While conclusions and crossed observations may be of help for stakeholders concerned by circular economy matters in the cities studied, the trends and the ideas drawn would hopefully inspire initiatives in other urban contexts, in Europe and beyond. In effect, rather than putting forward ‘clé-en-main’ reproducible practices, we focus on the recipe, the general design of the initiatives assessed. These may then be appropriated, adapted, and implemented in other contexts, including those located in the Global South.

Shifting circular, what is at stake for cities?

Since the beginning of the 2010s, the term circular economy has had an increased momentum, notably in Europe, in China and in the US, in academia, in public policies but also in corporate research and development strategies. In this research, we focus on the urban scale, reflecting on the infrastructures and policies that may turn conducive for a circular transition. What are we talking about? How is it an imperative?

Why do focusing on the local scale matter? What is at stake for cities? By the end of this report, we hope to put forward some answers, useful and able to inspire stakeholders concerned with initiating a transition away from linear supply chains.

Shifting to a circular economy is a move towards a re-insertion of policies and economic operations within bio-physical systems. Not that the economy has fully dematerialized, it is rather a reconsideration of the biophysical dimension of anthropic activities, assessing their material performances in a context where resource scarcity has become a public issue (again).

The circular transition admits the shift away from linear and extractive supply chains. While the classic linear economy boils down to extract, manufacture, consume and throw away, circular economy ‘turn[s] goods that are at the end of their service life into resources for others, closing loops in industrial ecosystems and minimising waste’ (Stahel; 2016, p.435). Besides this opposition to linear chains, shifting circular encompasses various definitions and perspectives implying different parameters in the way we design industrial processes, build infrastructures, develop public policies, and influence consumption patterns. While the Helen MacArthur foundation popularised the term in its report Towards the Circular Economy, published in 2013, previous theories and initiatives could be considered as proto-circular economy contributions. Three decades before MacArthur, Michael Braungart and William McDonough, for instance, put forward the need to shift from consuming supply chains to cradle-to-cradle ones, that would make the most from resources after their use by re-inputting them at the beginning of industrial processes. One should also have in mind concrete development that tried to make the most of the resources used. In this respect, Industrial Ecology initiatives are obvious references, as the one developed from the 1950’s in Kalundborg, Denmark. By creating a cooperative framework and establishing a governance of local material and energy flows - transforming the waste of one agent as a resource for another - this port city appears as a precursor in the creation of an industrial-environmental symbiosis.

Nowadays, circular economy has become a mainstream term: an increasing number of companies, governments and non-governmental organisations mobilise it as a complement to sustainability. This semantic hype is, however, not trivial. It highlights that supply chains, may these be local or not, need to be reoriented to account for material resource finitude. This bio-physical fact is an imperative: there is no doubt that maintaining the current ‘extract, manufacture and waste’ paradigm is not suitable for the functioning of modern economies in a context of resource

scarcity. Moreover, this weakness is even more weighing on economic resilience capacities since these linear flows rely on lean manufacturing practices and globalised supply chains, separating production and consumption areas.

The Covid-19 pandemic and the energy crisis that followed the Russian aggression of Ukraine are two events that recently stressed out these vulnerabilities, and the urgent need to lead such reflection on supply chain bio-physical rationalisation.

Shifting circular is a return to the material part of the economy. On the one hand, this implies a consideration of matter, its physical constraints and its scarcity, as the core of the governance of supply chains. Beyond their sole profitability, thinking in circular terms embeds these value creation mechanisms in regenerative processes in which material and energy must be considered and preserved as much as possible.

Material stocks must be looked after, and output flows be re-internalised to ensure the long-term conditions of economic prosperity. Matter matters!

On the other hand, the materiality of circular flows is linked with the scale at which such exchanges must be considered. While a circular shift implies a reconsideration of the dichotomy between producers and consumers (Savini, 2019), and a rapprochement between consumption and production areas (Kampelmann et de Muynck, 2018), such a transition requires the development of local supply chains, socio-spatially embedded.

Parameters of the circular transition make the city a relevant place to envision it. First, conceiving urban activities following a circular approach enables a full consideration of a given locality’s carbon footprints, by considering indirect emissions induced by consumption. According to C40 Cities, goods consumed within but produced out of urban areas, notably in Europe and in the United States, are the main sources of CO² emissions, before direct emissions (C40 Cities, 2018). Moreover, urban areas are consumption hotspots. It then appears worth considering these as mines from which important and steady material flows could be mobilised, reused, repaired, or remanufactured. Beyond reducing the scale of supply chains, thinking of the city as a circular hotspot may enable a better visibility of the production/consumption nexus, and trigger holistic initiatives reaching social and ecological co-benefits. Also, one must bear in mind the diversity of actors interacting in urban governance, including local governments, private actors, or civil society, that can contribute to the creation of common institutions,

regulations, and triggers, to better organise local material flows.

To help us grasp the challenges at stake, concepts of socio-environmental regimes and territorial metabolism are of particular interest. A socio-environmental regime highlights the ‘specific fundamental pattern of interaction between (human) society and natural systems’ (Fischer-Kowalsky & Haberl 2007). Adjacent to it, territorial metabolism encompasses the local interplay between natural processes and anthropological techniques; all material flows that circulate from, to and in a geographically defined system, whose boundaries, constraints, and resources are specific (Barles 2018).

Historically, the mainstreaming of linear and global supply chains could be traced back two centuries ago. From the innovations brought by the invention of the steam machine, we indeed shifted from a global agrarian socio-environmental regime to an industrial one, relying on fossil energies, expanding and accelerating supply chains and production patterns. While the acceleration of transportation means induced the progressive withdrawal and the lack of viability of local supply chains, counting on extracted resources independent from solar cycles triggered linear economic models based on one-way extraction. The mainstreaming of the industrial socio-ecological regime had two consequences for cities: the linearization of urban



metabolism and its externalisation (Kampelman & De Muynck 2018). Cities are, from this moment, heterotrophic economic locomotives, reliant on externalised and finite sources.

A circular shift would inevitably have to be multilevel. While this implies moving away from the industrial socio-ecological regime, it entails in parallel a modification of urban and territorial metabolisms, and a better control of local material flows. Then, to maintain the long-term conditions of local economic dynamism, reshuffling the deck by organising new infrastructures, triggering local productive capacities, and developing synergies seem to be sine qua non moves.

These call for new and specific activities, for deepened links between local actors and for nexus infrastructures to envision a new model for the production of the city. In this respect, the local governance of material flows beyond the sphere of the market entails a higher connection and equilibrium between residential and productive capacities, as already demonstrated in Brussels (d'Assenza-David, 2021). Shifting to a circular economy is part of a sustainable future yet to be designed, in which cities might inherently play a central and even leading role.

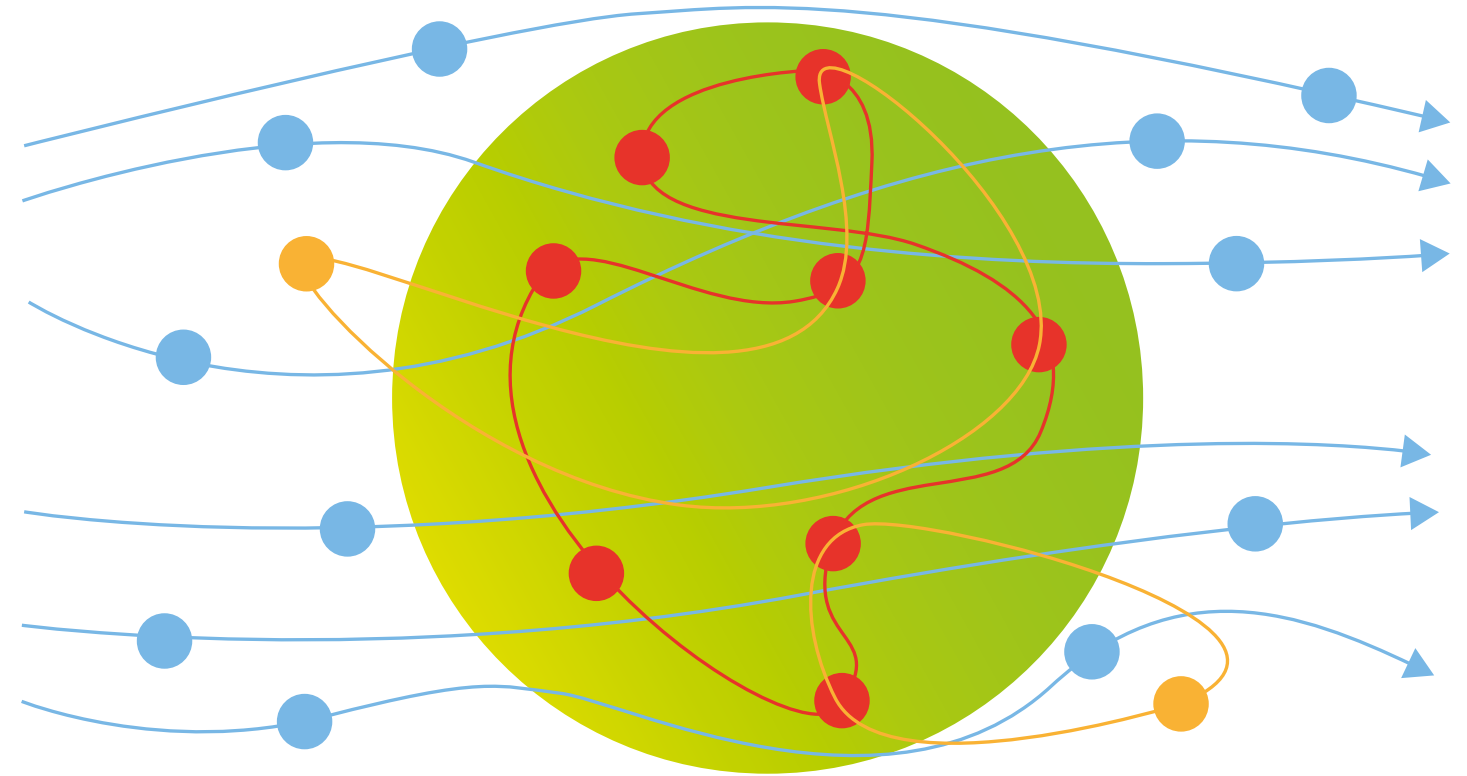
Rethinking urban capitalism: a threefold approach

Local strategies in favour of a circular economy could be framed in several manners and are context-specific. Despite this heterogeneity, similar trends could be identified when comparing these. Instead of identifying solutions and infrastructures that would be reproducible regardless of their specific needs, constraints and actors involved, we focus on the principles behind circular developments in the cities studied. On which philosophy public policies rely on? What are the properties of the infrastructures developed? Such insights would, as much as possible, be illustrated by examples. Elements provided in this short reflection are grist for

the mill to decision-makers to, perhaps, initiate and scale-up coherent initiatives. We hope that the confrontation between local expertise and this research would be conducive to further reflections to enable local stakeholders to seize the opportunities offered by the circular imperative.

Following a synthetic and comprehensive approach, we have elaborated and structured our reflection in a threefold manner. Three chapters successively provide mutually dependent perspectives from which we could approach urban circular transitions. First, circular cities must be understood as hubs for material flows: surely the most obvious when talking about circular economy. While a growing majority of the world's population lives in cities, where most consumption takes place, this is also where most by-products and waste are discarded. These constitute massive and steady material flows that are transiting through large-scale logistics infrastructures connecting cities between each other. In the initial chapter, we first highlight policies and initiatives to first identify, quantify and map these material flows. Then, specific attention is paid to policy interventions and infrastructures that, in each metropolitan context, play or could play a conducive role for the development of localised supply chains connected to urban metabolism. To conclude this first building block, we highlight some inspiring initiatives and mechanisms to trigger research and development on these questions and overcome current technical and policy barriers for the starting up and the scaling up of such localised circular supply chains.

In parallel, the circular city is necessarily a multifunctional and dense space that should strive for maximum efficiency. While circular economy opens a reflection on the materiality of urban economy, it also appears worth considering the materiality of the city. Where, and how, do material flows embed in the urban fabric? How are these processed? Under relatively high speculative pressure, the most populated and dynamic urban areas need to make room for vital activities for their territorial metabolism, as close as possible from consumption hubs. In other words, and as put by the Leipzig charter, striving for renewed sustainable development requires a new balance between residential and productive functions in cities. In this contribution, we then highlight initiatives to trigger an optimal balance of functions and allocation of urban land to reach the circular imperatives. As it could be done for material flows, we put forward, in a second chapter, initiatives to establish a territorial inventory of existing and required physical infrastructures, facilities, and land, to concretely reorganise urban productive apparatuses in favour of the circularisation of urban metabolism. From this diagnosis, we present urban planning and architecture initiatives to enable key urban functions to settle in relatively dense urban fabrics, thus reducing the gap between consumption and



The circular city as:

- a hub for the circulation of biophysical flows (1)
- a geographically defined space functionally allocated and constrained (2)
- ● a network of socio-economic stakeholders constituting urban governance (3)

Three dimensions to figure out the Circular City (© Hugo d'Assenza-David). Format slightly changed for better readability.

execution areas. Then, we put forward some avenues to trigger innovation in line with the circular organisation and building of the city.

Finally, one of the key features to trigger a circular transition at the local level is, we argue, the need to establish a local governance of material flows at the scale of urban life basins. In this respect, the circular city could also be understood as a hub to produce policies and regulations. Each urban context is subject to its own constraints and needs: some margin of manoeuvre is required to develop context-based solutions. The socio-ecological implications and consequences of a circular transition would be heterogeneous and should be envisioned with a precise and contextualised view on ecosystems. Adopting such an approach seems essential to further establish synergies and mutual dependencies between economic players operating within the same area, but also with relevant institutions and civil society. The last chapter sheds light on the governance implications of the circular imperative at the urban level. While we first put forward key initiatives to trigger the development of local industrial and circular clusters, we then mobilise

examples to show how useful local training schemes in line with the skills required for the circular imperative could be. In the end of this chapter, and before jumping to the conclusion, we reflect on the perspectives the circular imperative opens for the redefinition of prosperity to embed these newly visibilised bio-physical constraints into wider, collective, and progressive narratives.

The Amsterdam, Hamburg, Paris, and Brussels cases would be compared in a crossed manner within these three successive blocks. Each of them covers the distinct infrastructures, physical or not, to be considered in designing the circular city. However, these should not be understood as impermeable boxes: these are intertwined and should be approached holistically to reinforce each other. From this, it is up to each to identify useful insights to apprehend and create a coherence to each situation.

Case studies

circular supply chains for construction materials, biowaste and consumer goods would then be the first moves to shift to an alternative model of development. In line with national objectives, half of materials going through the city should be circularised by 2030, and all of them by 2050.

Amsterdam ambitions to become a circular model. While urban actors are prompt to present themselves as European green leaders, Amsterdam public institutions or private ones are regularly involved in international panels and horizontal cooperation schemes. For instance, the municipality initiated and led the Eurocities taskforce on circular economy to trigger circular policies in other European urban areas.

In this research, we focus on the municipality of Amsterdam, but also on its metropolitan region. While it is of particular interest to see what policies and infrastructures have been developed in this circular pioneering hub, it appears as an interesting case in which challenges ahead, barriers for further developments, are shared or will be shared by other urban areas.

Amsterdam

When reflecting on European cities developing circular strategies, Amsterdam is an obvious case. From 2014, the city was the first to embrace the circular economy concept, calling for a shift of its model of development, away from linear supply chains. Pushed by the port of Amsterdam, the fourth biggest European cargo port, in cooperation with the Amsterdam Metropolitan Region and the Amsterdam Economic Board, urban stakeholders launched a series of dialogues to trigger circular business models and launch prospective research to identify the main local opportunities. Key sectors were identified, and partnerships were established between local governments and key entrepreneurs, including biggest players and niche SMEs (Cramer, 2020). In 2020, the municipality of Amsterdam, the core of the metropolitan region, released its circular strategy that, for the first time, is part of a wider urban strategy to implement Kate Raworth's Doughnut theory. The development of



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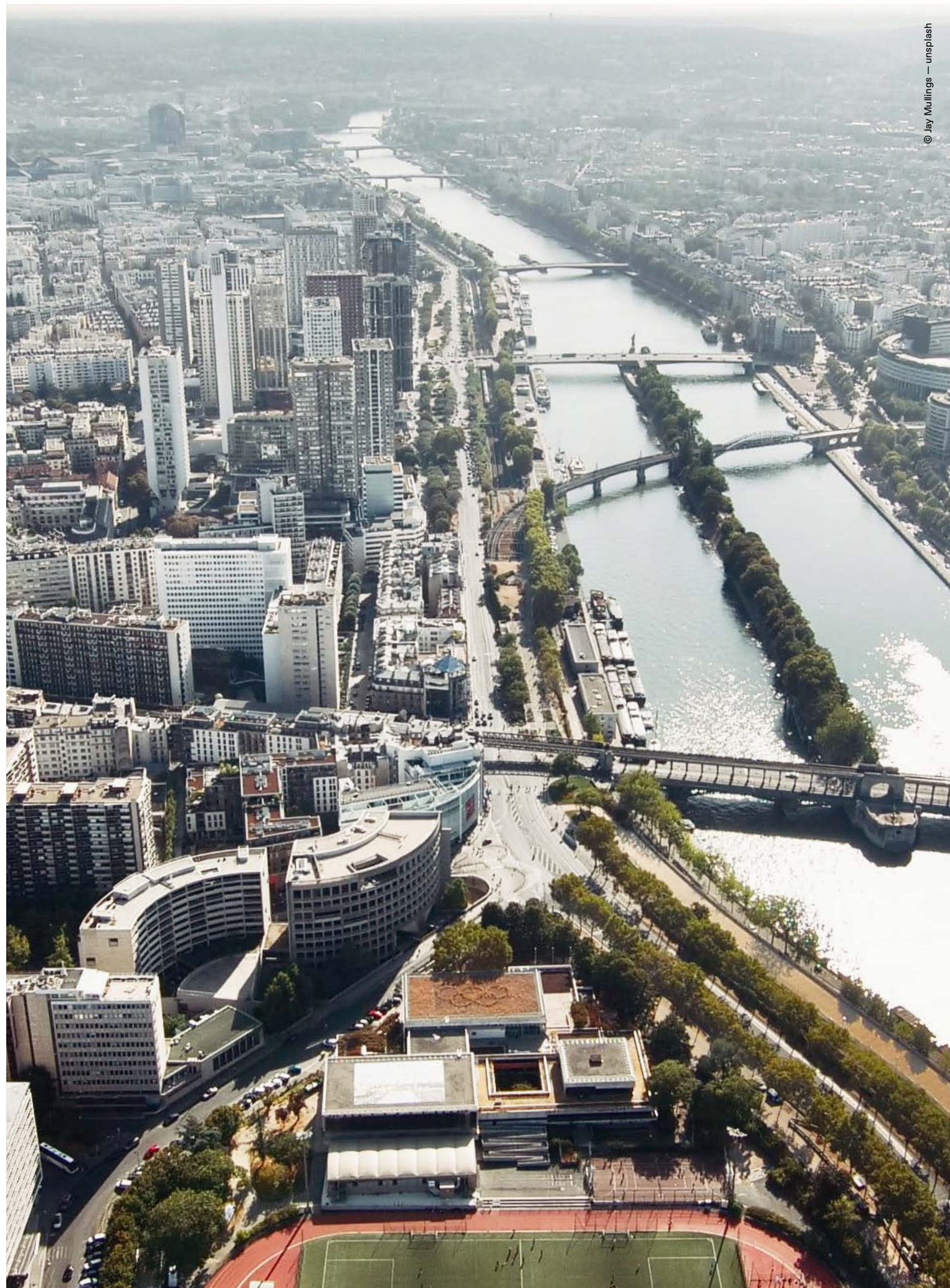
Brussels

Affected like most large cities by deindustrialization since the 1970s, to the point of becoming one of the least industrialised metropolises in Europe, Brussels is now a pioneering urban region with a strategy of diffusing industry into the urban fabric. As the spearhead of this policy ambition, Citydev is a public company created in 1974 with the mission of protecting and maintaining employment linked to productive activities, whether craft or industrial, in Brussels. More recently, this agenda was put into perspectives with considerations related to the ecological transition and urban metabolism. While the region has been one of the first urban areas to carry out a material flow analysis (MFA) to have a better vision on how these enter, circulate, and exit territorial boundaries, public authorities initiated, from 2016, a circular economy regional plan (PREC)

in connection with the existing ecosystem of regional public institutions. With a particular focus paid to the economic and job opportunities opened, the PREC aims to (1) transform environmental objectives into economic opportunities; (2) anchor the economy in Brussels in order to produce locally when possible, optimise the use of the territory's resources and create added value for the people of Brussels; (3) and create employment (Be.Circular, 2016).

Focusing on Brussels is of particular interest. On the one hand, it is worth examining how policies and stakeholders manage to combine different urban functions, notably the ones that are crucial for a circular economy, in the constrained area within the Brussels-Capital region. On the other hand, it is worth focusing on a city-region, in which a metropolitan government has important prerogatives and margin for manoeuvre for the development of public policies. For this research, we focus primarily on initiatives developed within the Brussels-Capital regional territory, although with a loose attention to cross-border initiatives that are relevant for our case study. Even if the institutional context is specific to Brussels, it provides interesting insights on what could be done at the local level.





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The Greater Paris metropolis is an interesting case of a dynamic and diverse economic hub. Besides being a key financial centre, the metropolis kept important industrial capabilities with large logistics infrastructures located around inland cargo ports and airports, but also with major industrial clusters. For instance, the Grand Orly Seine Bièvre and the Boucle Nord de la Seine territories are both recognised as industrial hotspots of national importance. The Parisian economic development is also very contrasted. While the core of the metropolis is one of the densest in the world, the periphery is much less dynamic. The creation of the Greater Paris Metropolis partly ambitioned to equilibrate this trend and compete with other dynamic global metropolises.

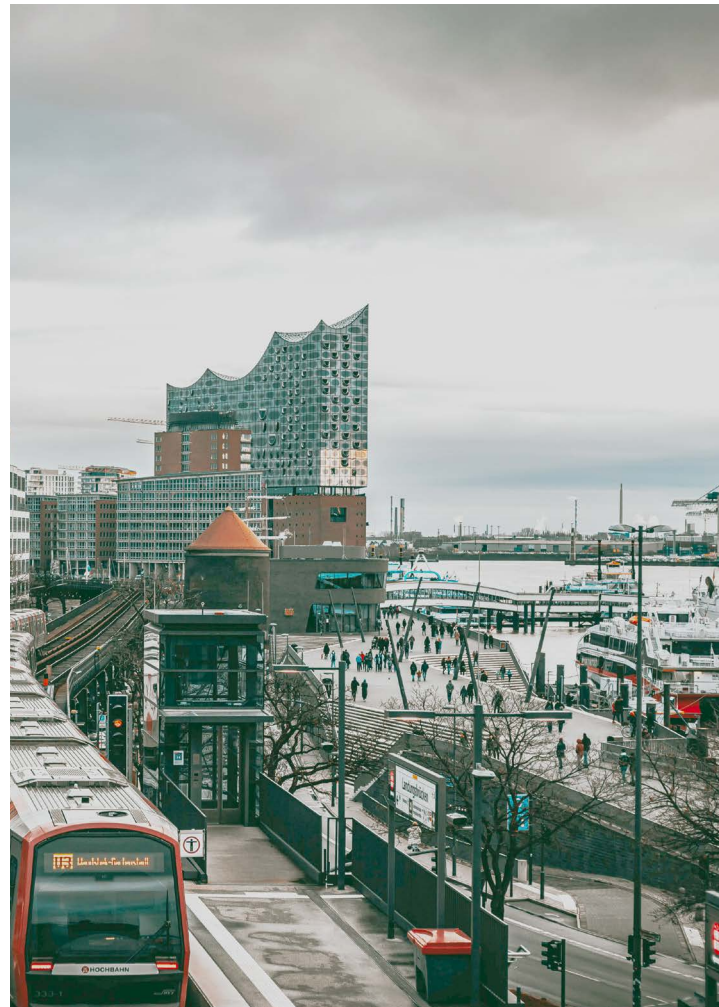
Paris is one of the frontrunner cities to initiate the ecological transition. While the French capital is regularly recognised for its ambitious policies, the city of Paris is particularly active in global municipal networks, including C40 cities or the Rockefeller's 100 Resilient Cities initiative. From this ambition also stems a circular economy strategy. From 2014, early discussions about the shift of the Parisian metabolism gradually led to a circular economy white paper from 2017 to 2020, in which the city council pushes for seven strategic priorities to be developed in cooperation with the metropolis. In 2020, the Greater Paris metropolis, in charge of economic development, took the lead in structuring its first metropolitan strategy for a circular economy. In connection with research and economic players, this initiative is now under development. The Parisian initiative is embedded in the French national strategy to transition towards a circular economy. Since 2021, more than half a million euros are allocated by the French government to support innovation in line with circular economy objectives and recycling. The priority is on eco-conception practices, and on the development of recycling and reuse solutions in five key material streams, including plastics, rare metals and textiles (French Government, 2021).

In this research, we focus on the initiatives developed in the Greater Paris metropolis to trigger the circular transition of the Parisian basin by favouring cooperation and synergies between different stakeholders, but also to maintain and develop a backdrop of key productive infrastructures in line with such transitioning objectives.

Paris



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Hamburg

materials in Europe: with a seaborne cargo throughput of almost 130 million tons, it is the third biggest cargo port of the European Atlantic range after Rotterdam and Antwerp. With its industrial-port area, Hamburg also hosts industries in key sectors including bio-tech, shipping, aircraft construction and raw materials.

Among the four cities studied, Hamburg is a contrasting example compared to the other cases, the one with the least formalised circular focus in local public policies. Even though there is no common plan, nor city's roadmap and strategy (yet), Hamburg is a vibrant urban area with many growing initiatives in line with circular objectives, and an increasing policy interest on these topics. By this, we would see that circular economy is not necessarily a shift impulse from the top, by public authorities. This is also a nascent sector that could be brought to the forth by research institutions, economic players and NGOs of different sizes. For instance, Hamburg hosts one of the most structured initiatives of the Fab City Global network, that aims at triggering local communities to produce as much goods as the city consumes, with a network of makers and SME's organised around this goal.

As for the last case study, we focus on Hamburg and its metropolitan region. This historical industrial and harbour city initiated, from the 1990's, the renewal of the city centre and the development of a sustainable agenda to modify its image. As the scale, the dynamism and the international reputation of the urban development in the HafenStadt district suggests, Hamburg intends to become, as well as Paris and Amsterdam, a European frontrunner in the ecological transition. Hamburg is also one of the gateways for traded goods and



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The circular city, or the biophysical rationalisation of urban metabolism

Key Takeaways

- *Establishing material flow and stock analyses enable contextualised diagnoses to identify urban mining potentials and trigger the development of local supply chains coherent with local resources and needs;*
- *Construction and deconstruction, textile and biomaterial industries are sectors with a high circular potential in urban areas;*
- *To structure supply chains in line with territorial metabolism needs, new business models should be found, and supported by public interventions – for instance through funding or through the provision of cheap facilities – to enable the expansion of small-scale initiatives and to structure circular sectors;*
- *Local research and development actors, whether they are innovative companies, research laboratories or even design offices, are interesting partners that need to be networked and connected with public policy issues in order to promote the percolation of new innovations into concrete practices.*
- *Public authorities should offer long term perspectives, or provide a direct support, to technical and policy innovations targeted in line with circular economy objectives and remaining gaps.*

When the circular economy emerges in policy discussion, it is necessarily related to material flows and supply chains. Indeed, the circular transition vehicles a change in the way (urban) economy is managed and pays a major attention to the biophysical processes. We could even say that the circular economy ideal precisely aims at putting such flows and stocks at the core of every economic and policy consideration. In this section, we highlight steps that, we argue, may be conducive for the development of local circular supply chains, their identification, the levers, and the development of new solutions to overcome barriers.

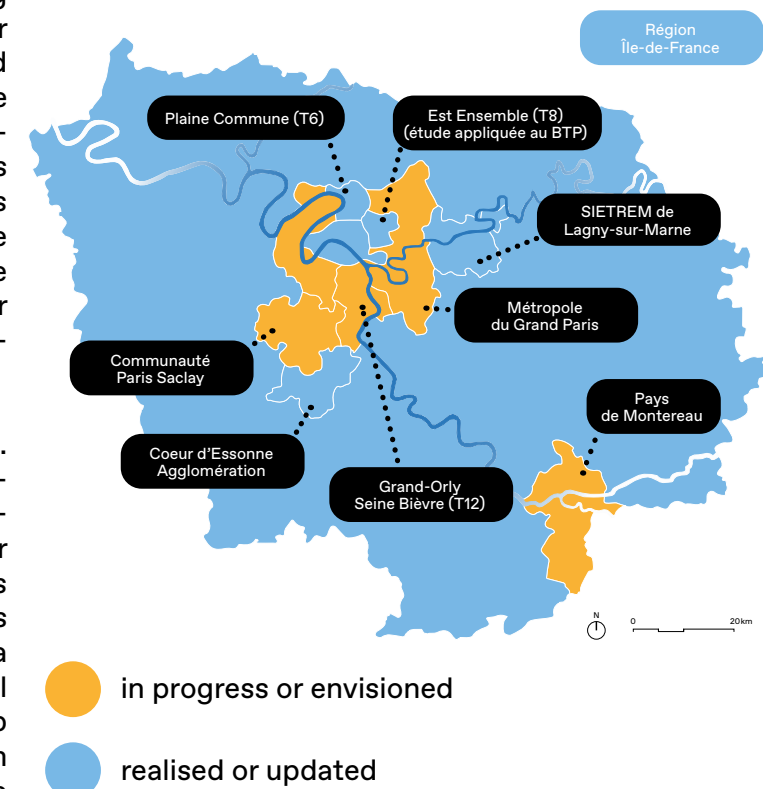
Developing contextualised diagnosis: what is the city made of?

When launching a local circular economy strategy, it seems central to develop a contextualised knowledge on the flows to deal with. On the one hand, it is about quantifying these. What resources does the territory need? In which quantity? Where are these coming from? What is done with used materials? To answer these questions, material flow analyses (MFA) could be carried out locally. In a defined system, may it be an industry, a city, or even a country, a MFA quantifies flows and stocks of matter, and thereby provides a biophysical perspective of supply chains, across sectors and operated locally at a given time. While the circular shift consists in bringing back matter at the centre of business designs, such diagnosis is key for decision-makers to jointly develop grounded and coherent policies.

A MFA is, by definition, bounded in time and space. However, modifying and comparing these two variables could provide key insights for the development of innovative public policies. First, the regular and long-term production of such analysis enables a performant tracking and assessment of initiatives deployed in a circular objective: while one MFA is a picture at a given time, regular updates of material flows quantification provide a dynamic follow-up of urban metabolism. The back and forth between policymaking and such diagnosis may enable more comprehensive and targeted interventions. In this respect, the Amsterdam metropolitan region is regularly subject to material flow analyses made by academic researchers, or by local consultancy firms like Circle Economy or Metabolic. MFAs then became key tools for Amsterdam stakeholders to base their circular economy initiatives on.

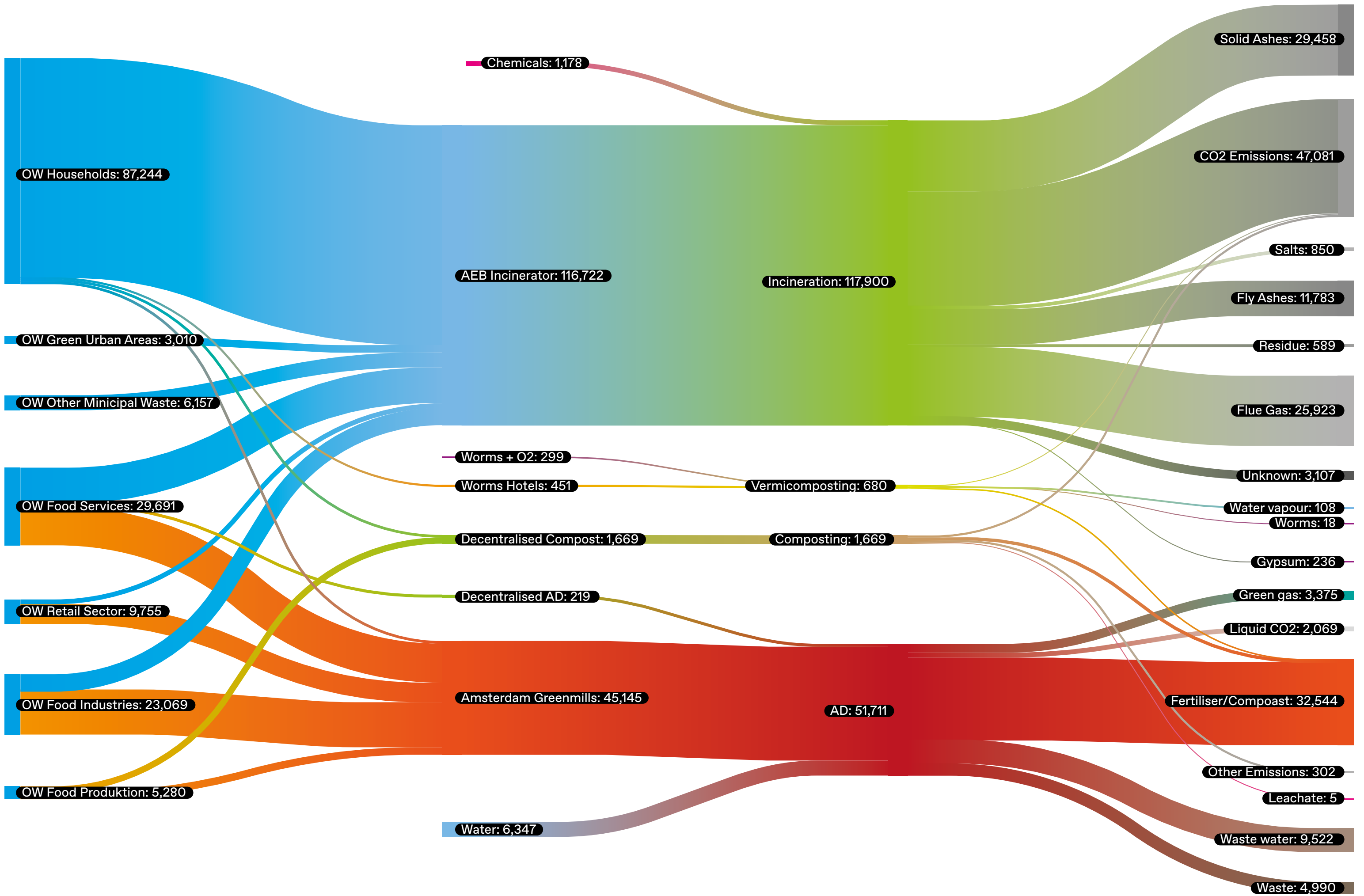
On the other hand, confronting MFAs from one scale to another may also be of great interest to capture the urban metabolism embeddedness into wider material networks. If an urban area is, by definition, sustained by a wider territory (not as localised as before, we have seen it) to cover its needs, establishing an impermeable material diagnosis provides only a partial vision

of the circularising potential. Then, it appears worth contextualising MFAs with both adjacent and wider territories to better identify synergetic and cooperative potentials between those. In this perspective, it is worth having in mind the diversity of material flow analyses that were carried out in the Parisian urban region. The city of Paris first reflected on its metabolic features in 2014, which, later, became the centre of attention for the Parisian general conference on the circular economy in 2015 and the development of the first Plan d'Economie Circulaire de Paris in 2018. In parallel, other agglomerations of municipalities around Paris - but also the Greater Paris metropolis and the Île-de-France region - developed their own urban metabolism studies (Vialleix, 2021). This diversity in the levels of analysis enables a precise vision on the flows circulating in the Parisian urban basin, highlights territorial specificities, and is key for the development of localised and coordinated circular economy strategies.



Territorial Metabolism analyses carried out in the Île-de-France region in 2020 or before
 (© Institut Paris Région - Public Domain) https://www.institutparisregion.fr/fileadmin/NewEtuDES/000pack2/Etude_2625/EtudesMetabolisme_Recensement_VF.pdf

It should however be noted that for most of the few cities that were subjects to MFAs, such diagnoses leaned on macro-scale data that lacked granularity to properly assess local dynamics at stake. When taking the example of European cities, such information on bio-physical stocks and flows is scarce. Consistent information could only be found at the regional scale, with Eurostat datasets at the NUTS III level. While this may be enough for the biggest metropolises (even though not satisfactory enough to assess neighbourhood and infra-urban dynamics), this precision does



not suffice for medium and small-sized cities embedded in wider regions. In this respect, it then appears worth triggering localised data gathering and reverse the logic, from a top-down to a bottom-up data collection with grounded expertise. In other words, establishing a specific diagnosis of material flows and stocks requires local institutions with human and financial means to estimate the bio-physical patterns of anthropic activities.

Such a knowledge may be constituted in cooperation with new kinds of business-to-business services that would surely gain momentum as soon as the circular economy mainstreams. For instance, *Resourcify* in Hamburg is specialised in the development and the selling of digital products to industries to enable them to follow, on a day-by-day basis, material inputs and outputs. Customers are then accompanied for the development of inventories and dashboards to monitor bio-physical flows and stock treatments in their industrial processes. While this type of accounting seems fundamental to initiate industrial transition processes, knowledge networking and data sharing also seems crucial to enable a governance of these material flows. On this point, legislative innovations and policy levers remain to be found to trigger such an openness.

In parallel to rather descriptive quantitative diagnoses, local biophysical patterns should also be qualitatively appreciated in characterising both lock-ins and potential adjuvants for their circularisation. To do so, it appears worth reflecting on supply chain properties by developing an in-depth understanding of the conditions for such material transformations and carrying out prospective inquiries to identify sectorial potentials. In this respect, initiatives in the Dutch capital are worth looking at. On the one hand, there is a local ambition to trigger a case-by-case follow-up of transformed objects and materials, to have a clear vision on the matter behind the existing city and to make the most of urban stocks. In the construction industry, the Madaster material passport traces, for each building, the materials used, and the techniques mobilised for its erection. Data is informed on an online registry. Triggering transparency, this passport enables the proper and efficient use of local materials and should become a significant adjuvant in future deconstruction or refurbishment projects. In the Amsterdam Metropolitan Area, the material passport is now at the core of a pilot project mobilising public authorities to trigger circular economy initiatives in the construction sector.

Additionally, establishing a local diagnosis also consists in determining local, regular and steady material flows mobilizable for the deployment of circular supply chains. While surveys could be addressed to local industries, waste management companies could also be

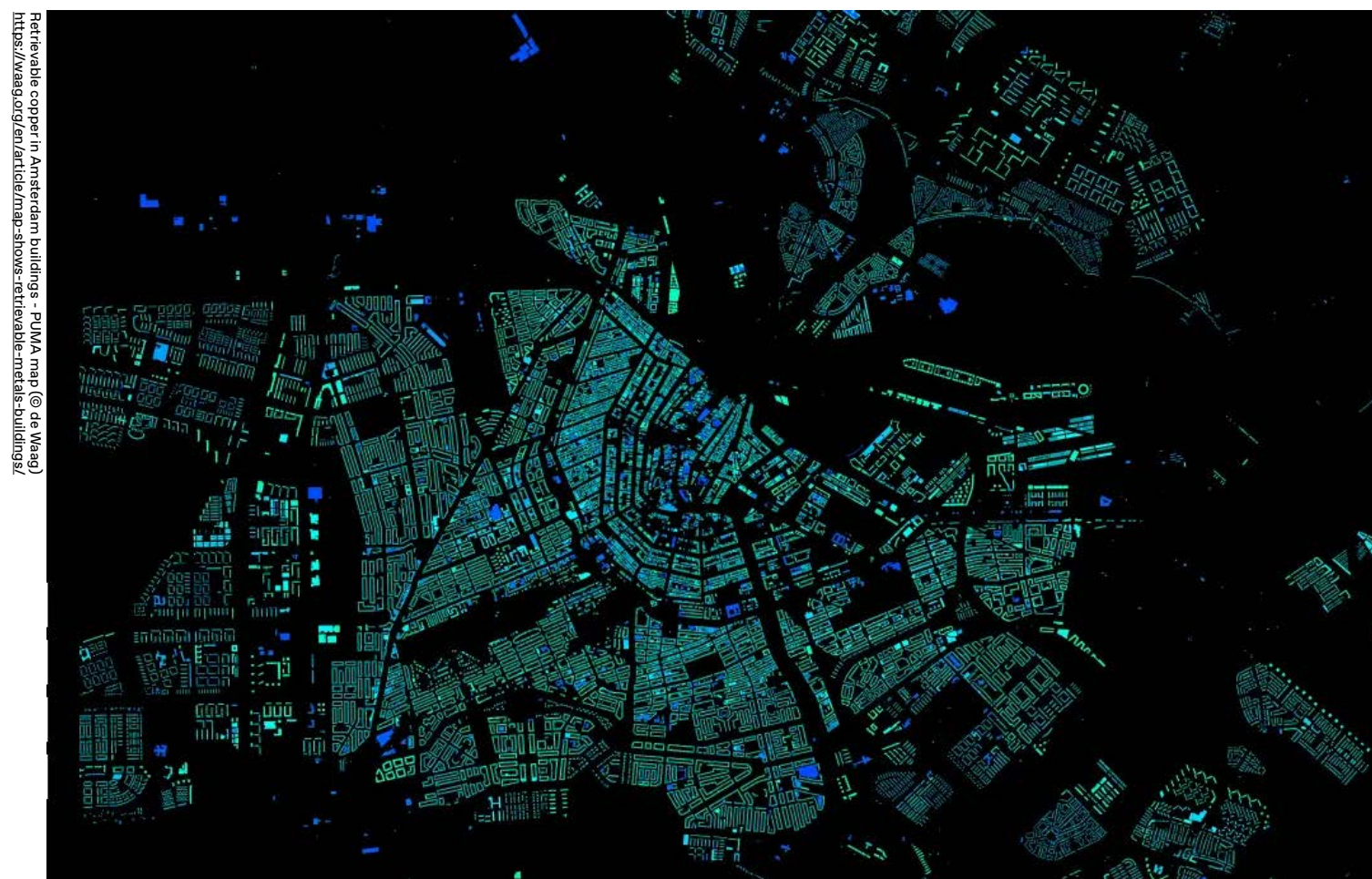
mobilised and supported to identify the composition of waste transiting through treatment infrastructures.

In Hamburg, as well as in other European cities, the *Circular Construction in Regenerative Cities (CIRCult)* European project triggers the development of circular practices in the construction and deconstruction sector to 'bridge the gap between theory, practice and policy by delivering a series of demonstrations, case studies, events and other dissemination activities that showcase how circular construction approaches can be scaled and replicated across Europe to enable cities to build more sustainably and transition to a circular built environment' (CIRCult, 2022). While the main objective of the project is to identify further policy developments and to establish generalisable proof-of-concepts, local bio-physical flows and urban mining potentials are mapped out by a consortium of public and private actors, including the city of Hamburg, the *Hamburg Technical University* or the consultancy cabinet *e-hoch-3*. Initial diagnoses are bases for developing awareness campaigns, training schemes and governance tools to extend the construction materials lifecycle and share good practices in the construction sector. In Brussels, one may also have in mind the key role played by *Recy-K*, a regional platform through which waste is being sorted and material inventories made. With the *Recy-K* expertise, regular and consistent flows of plastic were identified and constituted the basis for the development of new businesses in Brussels.

Other innovative methods could be developed to estimate urban material reservoirs. For instance, the *Prospecting the Urban Mines of Amsterdam (PUMA)* initiative jointly launched by the municipality of Amsterdam, *de Waag and Metabolic* seeks to identify and map material flows with the highest potential in the city. The PUMA methodology consisted in estimating the rough amount of copper and iron contained in the residential buildings of Amsterdam (based on proxies like building height). The total metal stock in each building was calculated by combining data on the presence and the number of constructions that contain known concentrations of metal (Koutamanis, 2016).¹

In the same logic, the *CENTRINNO* EU project also consists in establishing local diagnoses. In addition to supporting the redevelopment of former industrial areas, the European program aims to establish contextualised knowledge by setting up simultaneous research-action initiatives in a dozen urban contexts. Cartographic tools, Material Flow Analysis, but also questionnaires for key actors are developed since 2021. The characterization and localization of waste flows, as well as a detailed understanding of the

¹ Koutamanis, A. et al. 2016. PUMA - from building to urban mine (project proposal). Faculty of Architecture and the Built Environment, TU Delft, Delft, The Netherlands



Retrievable copper in Amsterdam buildings - PUMA map (© de Waag)
<https://waag.org/en/article/map-shows-retrievable-metals-buildings/>

interactions and practices of local actors, will make it possible to identify demands and resource flows to structure local value chains.

Establishing such diagnoses requires the development and the support to local research capacities, to provide grounded expertise. While skills could increasingly be found in universities and consultancy firms, public authorities may also act as adjuvant in building bridges, creating synergies beyond sectors, and triggering the circulation of information. Although it is a significant investment, one must keep in mind the potential of such basic knowledge for the structuration of new economic sectors. As we would see it in the next chapters, circular developments may be developed by small-scale actors with restricted resources. To unleash the circular potential in a given territory, decommodifying this data and making it accessible on open data platforms may also constitute strategic moves towards a circular economy.

In addition, to meet climate and environmental ambitions, the circular economy should not only be seen as a cottage industry: this transition should be made at a large-industrial scale to transform business and consumption practices. New supply chains have to be designed, and their concrete structure in the pre-existing regimes may be triggered by some sorts of interventions.

Building on opportunities and needs: towards local supply chains

Once the diagnosis is established, local initiatives at the city level may also contribute to the structuration of local supply in line with circular objectives. First, such push requires an effective management of urban waste, in the collection, the sorting and the distribution stages. While cities are, by essence, the main producers of wasted materials, a priority must be given to reorient these flows and transform these into resources. This could consist in raising awareness among companies, and in establishing connections. Following an industrial symbiosis logic, waste from a first business could constitute the resources of a latter. In this respect, developing business-scale material accounting, as proposed by *Resourcify*, and their connection, could be a serious adjuvant to identify potentials for synergies. Similarly, consumption waste could be traced at the infra-urban level and directly targeted for the structuration of supply chains.

Another lever for the efficient management of waste for the structuration of local supply chains is the

development of reverse logistics. While this sector is the arterial network at the core of supply chains, circular circuits require business innovations not only to deliver manufactured and transformed goods, but also to ship those that are consumed to spaces of transformation, to give them back a value. What would a profitable full-logistics business look like? *SUMY* logistics, located in the Brussels Capital urban region, has its own answer. Pioneer of reverse logistics in the food sector, *SUMY* delivery trucks do not only hand over fresh food to shops and restaurants: they also retrieve their bio-waste to valorise it into bio-gas power plants that, in the end, fuel delivery trucks. While reverse logistics help develop circular circuits at the business level, the same logic could be applied to a whole sector. For instance, in Hamburg, a whole supply chain structured around detergent packaging waste. From a new liquid container made from locally gathered plastics, the Hamburg bottle is about recycling wasted bottles by connecting all partners of the supply chain. The reused bottle is then a binder between *Stadtreinigung Hamburg*, who gathers plastic waste, *Veolia* and its recycling operations, *Unilever* who fills the bottle with new detergents, and the local retailer *Budni*. This practice may be a source of inspiration for other cities to develop local supply chains. For the *Hamburg Bottle* promoters, closed loops with plastics ‘can be established in almost all regional areas’ (Interreg Europe, n.d.). Even though ‘the size of Hamburg (almost 2 million inhabitants) makes it easier to reach a critical mass of consumers and amount of resources [...] the principle is transferable to regions of every size (Ibid)’.

Developing local and circular supply chains is not a given, even once steady material flows and stocks are identified. Markets are dominantly structured on global supply chains for a maximisation of profits based on minimum labour and optimisation of transport costs. Structuring circular supply chains requires an alternative approach based on the optimisation of material and energy use. Even if it appears key to modify (inter) national trade policies, notably by modifying the nature of taxes to promote material and energetic moderation, local development policies can play a stimulus role in the meantime. This highlights a renewed role to be played by public administrations. Beyond direct interventions to structure publicly owned businesses in charge of managing common good resources, conceiving local governments as strategists highlights the potential for partial interventions to launch, ensure and protect key supply chains for local resilience. Following this idea, public authorities could help structuring specific loops meeting the needs identified in the diagnosis phase. These refer not only to the input resources to feed urban metabolism, but also the outputs it generates. In this perspective, one may have in mind the role played by *Hub.Brussels*. Backed by the Brussels Capital region, this organisation calls for

tenders at the destination of economic entrepreneurs to structure economic ecosystems around key policy objectives. Strategic sectors organised around specific material flows and stocks could notably be supported and financed. With such intervention, industrial grapes are being designed from materials available locally, and in line with regional needs. For instance, a whole circuit has been developed from textile scraps. Through a public contract initiated in 2018, a textile production chain to recycle by-produced scraps in the region was encouraged. With its circular jacket project, *Isatio* won the tender by organising a complete supply chain - i.e. the reception of textile offcuts, the production of circular jackets and their distribution with sustainable logistic support. Since its launch, this 100% local system generated dozens of jobs and was made possible by the intervention of *Hub*, whose ambition is to develop and reproduce this approach for other sectors.

Some material flows and stocks seem to be particularly consistent in urban areas and may constitute local re-manufacturing potentials. In the image of the production chain structured around *Isatio*, textile material flows have a promising manufacturing potential in cities. In Amsterdam, a whole economic ecosystem emerged and tries to be ahead of the curve. As the spearhead of this transitioning ecosystem, *MUD Jeans* fully embraces the circular economy principles in the textile sector. Launched and based in Almere, the second biggest municipality in the Amsterdam urban area, *MUD Jeans* are made at 40% from discarded jeans. The innovation also lies in the business model. Instead of selling its production, the Dutch company leases the jean on a renewable one-year contract at the end of which the customer can, if he wishes, switch them. The contract also includes free unlimited repair services.

In cities, the construction sector is also a major source of material flows. Retrofit practices and the use of wood for new buildings is, for instance, pushed in Hamburg by local authorities. On the one hand, the City of Hamburg systematically examines, in demolition projects, the renovation possibilities to avoid useless grey emissions induced by the construction of a new building. On the other hand, when new buildings are about to be erected, the use of sustainable materials is favoured. While public constructions are increasingly made with wood or recycled materials, like RC-concrete, private construction projects are incentivised to do so. Beyond seminars and information sessions held by the *Hamburg public investment bank (IFB)*, local regulation has been adapted and a public subsidy of 80 cents per kilogram of wood used in the construction process is proposed to private applicants.

Another key urban flow could also be found in bio-based materials. In this respect, the Parisian *CENTRINNO* project highlights the need for micro scale initiatives in the food sector. In connection with the *Verger Urbain*

cooperative, they notably launched the *Jardins de Traverse* pilot project. Located in a 7000m² space, an abandoned railway track in Paris, it aims at being both a local meeting place and an incubator for start-ups and SMEs in the urban agriculture sector. In parallel, the Parisian *Fab City Hub* located in the Mouzaia district has also been thought as an incubator for small-scale businesses, and a meeting place for stakeholders pushing for the development of urban manufacturing initiatives in Paris. In contrast, stakeholders in the port of Amsterdam are structuring an industrial symbiosis for the creation of biofuel from urban biowaste. In accordance with the port and the municipal circular economy strategies, biowaste in Amsterdam will increasingly be collected separately at the neighbourhood level – as experiments demonstrate it in the Java and Zuidoost districts – and transferred to companies located in the port to structure a biogas and biofuel sector. A whole industrial synergy is being organised around *Renewi*, a waste treatment company that recently developed a new bio-gas plant in the port. With this approach, local actors kill two birds with one stone: while urban waste is recovered rather than incinerated, it is reused to structure local economic channels which, at the same time, makes the activities of the port more sustainable by using bio-sourced instead of fossil fuel.

To accompany the development of innovative initiatives, it could also be key to structure specialised incubators as sanctuaries for new emerging circular businesses, yet fragile in incumbent sectorial regimes. By providing financial incentives, business to business services, networking opportunities but also physical infrastructures (we would come back on that point), targeted hubs are heartbeats for the sustainable transformation of urban economies. Eventually, when these are backed by public subsidies, they offer the possibility for early birds to launch businesses in line with political priorities in terms of jobs created or material flows mobilised. In Brussels, *Hub.Brussels* has developed *Be.Circular*, a hub specifically designed for the development of circular businesses in the Brussels urban region. While it connects hundreds of regional entrepreneurs, decision makers and civil society stakeholders, *Be.Circular* offers subsidies, initiates bootcamps and triggers synergies between those. In the same vein, one may have in mind the action of the port of Amsterdam that recently opened *Prodock*, an incubator for the development of new sustainable businesses in the industrial-port area. While the port of Amsterdam, in cooperation with the municipality, tries to diversify the harbour’s activities by favouring a cradle-to-cradle approach, hence making the harbour a ‘battery for the city’, *Prodock* acts as a breeding ground for new entrepreneurs that incrementally modify the kinds of activities hosted by the fifth biggest European industrial port.

The structuration of new supply chains also highlights the need to rethink the panel of services and facilities

we provide to productive companies. Beyond cost considerations, these key features may be central components for economic stakeholders in their settling choices. In this respect, it is worth having in mind the role *Fab Labs* could play in such an economic dynamism strategy. These relatively new urban objects are third places grouping together several machine tools made available to small entrepreneurs or individuals. *Fabrication Laboratories* are, for most of them, non-profitable and developed as subsidised associations or within research laboratories (public or private). Their functions and business model have yet to be identified. In the course of this research, it was interesting to see how these infrastructures can be serious adjuvants for triggering a transformative circular transition as services to businesses, enabling them to prototype new models or to pool production resources. Also, they are spaces for practical training that can, as we will see later, foster the emergence of new productive cultures and the upgrading of urban workers skills. While these new third places are, for most of them, run by maker cooperatives and associations, it appears that combining their assets and expertise with local attractivity projects could be particularly transformative. In Brussels, in the business parks developed by *Citydev*, *Fab Labs* are a key component of the strategy: aside from being experiment places for grassroot makers and citizens, these may also be put forward as included services at the disposal of companies for their research and development activities. Indeed, some machine tools in *Fab Labs* are particularly expensive (think about a water cutting machine for instance), and unaffordable for SMEs. By mutualising the buying costs of such instruments, the *Fab Lab* of the *Citydev’s City Fab network* proposes a low-cost access to entrepreneurs who could benefit from these machines during a given time slot. Beyond this, members of the *City Fab network* recently launched the *Microfactory* project. As a cooperative, *Microfactory* bought machine tools that could be used as much as cooperative members wish, during specific time slots. Based on the mutualisation of production means, such initiative not only maximises the investment made, but also constitute an attractive option for new businesses wishing to settle a productive activity, with limited financial means.

The structuration of new supply chains is at the core of the circular transition. However, structuring circular loops, or transitioning away from incumbent circuits, could be, for now, an obstacle course. While following a circular trajectory remains a risky choice for entrepreneurs, many would argue such a transition is, in their sector, apple pie rhetoric, or, at best, possible but unaffordable. Consequently, it appears that operating the circular transition of productive patterns requires a change on the finalities markets prioritise within sectors. While most of the rules are settled beyond the local level, policies at the urban scale could be of help to restrict this uncertainty.

Orienting and pushing circular innovation

The shift of urban metabolism from a linear to a circular model requires a reduction of the uncertainty attached to this transition. At the local level, the lack of prospects for potential circular entrepreneurs could be tempered by mechanisms to both target and accompany innovation, but also to ensure end markets. On the one hand, re-orienting innovation efforts could be central to unleash the circular potential and valorise initiatives that intend to reduce and recycle both materials and energy used. Perspectives for innovation may also be framed according to the stock and flows identified on a given territory. This is where local governments are of particular importance. Authorities in charge of economic development policies may be inspired by making bridges between existing and growing businesses, and local bio-physical diagnoses established previously. When some existing material flows, stocks and needs are identified, initiatives to foster research and development in line with these priorities would not only enable their efficient management but would also contribute to establish local sectorial advantages with economic and social impacts.

Concretely, this may consist in emitting calls for tenders, as the *Hub.Brussels* tender for textile scrap. Another tool with a great potential if mobilised efficiently are specifications in public procurements. Whereas most of those do not mention anything on that matter, local governments may play a role in explicitly asking service providers to account for local specificities and deliver circular products: recycled, mobilising as less resources as possible, reusable, or eventually recyclable. By doing so, the orientation of public markets may trigger an incremental re-orientation of whole sectors towards circular goals. In the building sector, the city of Amsterdam mobilises such a tool. From the 2020 circular strategy onwards, public tenders specifically ask future contractors to establish quotes including a circular section, considering the whole life cycle of buildings erected. For instance, a circular road has been constructed in the Amstelstad district. Instead of a public buying, the road property remains with the construction company, who is also responsible for its maintenance of the road. This leasing instrument enables a closer management of the resources used for the road and opens new perspectives for its upcycling in the end of its life course.

Another lever lies in the funding of initiatives and businesses in line with socio-ecological objectives. In this perspective the regional public organisation *Innoviris*, in Brussels, connects, stimulates and financially supports companies, research and non-profit organisations by setting up subsidies. These incentive funding programs are created to encourage and stimulate the development of a territorial ecosystem for innovation in different areas. In 2018, out of a total of 46.17 million invested, *Innoviris* financed 327 projects and generated 548 jobs in companies and research organisations. Many of the projects financed are circular. In parallel, *BruCircle* is a lever developed by the public organisation *Finance.brussels*, allowing equity investments or loans of up to 200,000 euros at the destination of businesses who develop their businesses following a circular economy approach. For instance, the reverse logistics company *SUMY* received the first *BruCircle* loan of €150,000 in 2019 for its innovative action. In Hamburg, a similar funding scheme has been settled by the *Hamburg Public Investment bank (IFB)*. *PROFI Environment* (individuals) and *PROFI Environment Transfer* (collaborative projects) supports the development of 'innovative products, processes or services that 'contribute to climate and environmental protection [with a focus made on] on resource and material efficiency and improvements in the circular economy' (IFB Hamburg, n.d.). These grants, up to €1 million (€500,000 for individual projects), are available for businesses of all sizes, from all sectors and also concerns universities and research institutions. The only condition for obtaining such a subsidy is permanent residence in the city of Hamburg.

More direct interventions could also be envisioned to target more explicitly innovation efforts. In this respect, the *Cycle Terre* initiative developed in the Parisian metropolis is of particular interest. Since 2020, this consortium of public and private stakeholders, including the Greater Paris Aménagement, Quartus or the City of Sevran, aims at pushing the use of raw earth in the construction sector. Based on the observation that the *Grand Paris Express* subway development would generate a total of 43 million tons of excavated earth, and that constructions in the Greater Paris would generate almost ten times this volume, stakeholders involved in the *Cycle Terre* demonstrate the recycling potential of this material for the construction sector, by implementing all the steps for structuring a local sector. This includes the launch of a production line of construction materials from excavated earth, the production of technical benchmarks and labels, and the promotion of sustainable methods to architects and real estate actors. In total, *Cycle Terre* is a bridge, an urban and industrial symbiosis between two economic activities: 'the first producing material (excavated earth on the site of the Greater Paris subway stations), the latter consuming material (urban construction projects within the framework of

the *Terre d'avenir* joint development zone). It takes the opportunity of the spatial and temporal concordance of excavation sites clearing earth on the one hand and the construction of new urban districts on the other to set up a closed loop of flows' (Bastin and Verdeil, 2020). In parallel, *Cycle Terre* aims at developing training schemes for locals and construction sector companies, but also pushes for transferring these practices in other areas of the Greater Paris region, and in other European cities.

To trigger innovation, supporting prospective and academic research could also be constitutive of a local strategy to structure circular sectors. For instance, the Greater Paris Metropolis jointly launched with the *Gustave Eiffel University* – specialised in urban issues – the *Circular Economy and Urban Metabolism chair*, aims at developing a scientific expertise on these topics. On the one hand, the research team creates academic contents, develops contextualised synthetic notes with recommendations, but also organises events and seminars to trigger a dialogue and cooperation between circular stakeholders in the Greater Paris metropolis. On the other hand, the chair also breeds operational tools to support the Greater Paris circular strategy. For instance, the *EVALMETAB* tool has been launched in 2020 to assess the metabolism of real estate projects from the characteristics of the buildings, existing or under development. While it enables a quantification of material flows generated in the construction phase, it also approximates the costs and the emissions induced by the transportation of these bio-physical flows from the nearest production site, or to the nearest treatment infrastructure. In a

similar vein, the *Amsterdam Metropolitan Studies (AMS) Institute* is a key institution in the structuration of a circular economy in Amsterdam. With a transdisciplinary team specifically working on the development of local circular initiative, and in cooperation with the Municipality of Amsterdam and three universities – the *Technical University Delft (TUD)*, *Wageningen University and Research (WUR)* and the *Massachusetts Institute of Technology (MIT)* – the AMS Institute finances research projects and establishes links with key economic sectors. With such a triple-helix approach, specific knowledge is created from the concrete needs highlighted by Amsterdam stakeholders, solutions and innovations are found and developed by partner universities, before being implemented by economic partners, or by incubated businesses.

In this first chapter, we have highlighted some pathways to incrementally trigger the circularisation of material flows. It appears that local public interventions and the use of policy instruments are key to trigger market developments in line with existing flows and needs. Such intervention, we argue, should not only consist in accompanying the structuration and the re-orientation of supply chains, and support related innovation. It should also consist in localising them through an efficient arrangement of urban land, to enable key functions and infrastructures to localise within or near the city.



A delegation of Indian ministers visiting the International Fair Trade Association (IFAT) 2022 in Munich to meet German entrepreneurs for waste treatment technologies © GIZ GmbH

A circular approach to urban land

Key takeaways

- *As for urban material stocks, establishing contextualised diagnoses of infrastructures enable an identification of the existing and missing functional assets - including technical and logistic hubs, waste treatment plants and re-manufacturing facilities - to circularise material flows;*
- *In parallel, the identification of available land and existing industrial brownfields locate key infrastructural (re)development potentials, and the location of available land for material flow manipulations;*
- *To maintain or develop circular urban functions in cities, it appears central to cap speculative practices through new types of public intervention – i.e. through urban planning regulations and land acquisitions – and to develop new forms of activities at the interstices left by market, for instance by encouraging temporary occupations;*
- *In order to limit the use of raw materials and long-term deconstruction costs, the eco-concept should be placed at the center of the design phase of urban measures, e.g. by using materials from previous deconstruction measures or by applying reversible urban or deconstruction construction techniques;*
- *From an architectural perspective, a circular approach to land also consists in making sure residential and productive functions fit and interact within a constrained space, hence requiring further research and development for horizontal and vertical mixed-uses.*

The shift away from linear to circular supply chains is not only about declaring and imposing the rationalisation of biophysical flows and stocks. It is also about deploying the infrastructures required to intervene on these. In this respect, there are specific stakes for cities. As main consumption areas, urban fabrics are relatively dense, which makes it particularly challenging to bring productive and operational functions closer. In this second section, we assess some of the strategies, initiatives and policy innovations to build the functional symbioses required for a circular city.

Establishing territorial infrastructural inventories, or the identification of local assets' circular potentials

As this could be done for bio-physical flows and stocks, designing the circular city also consists in establishing a diagnosis of the infrastructural resources at disposal in and around it. The shift of some material flows from a linear to a circular model requires a functional backdrop; a network of physical spaces embodying the key steps of new circular supply chains. From one territory to another, the required infrastructures change, depending on the kind and the quantity of bio-physical materials identified. Most of the time, however, the same kind of physical spaces are required: logistics lots, facilities for waste collection and sorting, but also re-manufacturing facilities to ease the reuse, the repair, or the recycling of goods. Then, what are the infrastructures a locality can dispose of? Where are these located? What land could be used to develop new ones? To answer, the regional institution perspectives.brussels launched, in 2012, an observatory of productive activities that regularly publishes reports and diagnoses on the state of these sectors and related infrastructures within the Belgian capital. Even if this initiative has been designed to monitor the expansion of the third sector and maintain industries in the city, the knowledge created may also be oriented in a more strategic manner and aligned with the circular and resilience ambitions of local authorities.

Developing such knowledge enables a better vision of what infrastructures operate within a given territory. Local stakeholders may lean on them, and on the associated expertise, to foster new circular supply chains. In addition, this identification represents a list of local assets that can be mobilized in the medium and long term for new sectors to be created as part of a circular economy. Precisely knowing where these infrastructures are and what they do may be of key interest as markets restructure in line with circular objectives. Core infrastructures may indeed be maintained and potentially re-oriented towards local flows.

Complementarily, establishing such a diagnosis and confronting it with local bio-physical characteristics and needs could also enable a better identification of the kind of infrastructures that need to be developed or expanded to properly manage flows and stocks.

These priorities could be put forward in holistic circular economy strategies. In Hamburg, despite the diversity of stakeholders who advocate for circular approaches, may it be SMEs, start-ups, cooperatives or even associations, there is, as opposed to Brussels or Amsterdam, no holistic circular economy plan structured by local authorities. When we write these lines, such a policy strategy is under development, and pushed by the *Hamburg Authority for the Environment, Climate, Energy and Agriculture (BUKEA)*. To design it, *BUKEA* called upon the *Wuppertal Institute*, a German think tank specialised in energy and resource efficiency matters. By mobilising a transdisciplinary team, the *Wuppertal Institute's* mission is about identifying the key sectors, stakeholders but also infrastructures on which authorities could lean on. In other words, while business and civil society actors are already ahead of the circular curve, local governments have a clear interest in developing localised knowledge to identify and map adjuvants for a circular transition.

It is also worth noting that *CENTRINNO* initiatives also aim at mapping the existing stakeholders, infrastructures and institutions that may be conducive for the development of circular and localised supply chains. From these bases, and from material flow analyses, *CENTRINNO* stakeholders ultimately aim at (re)deploying distributed manufacturing activities – notably in urban brownfields – in line with circular economy principles.

One may also have in mind the European *REPAiR* initiative, whose 'ambition is to investigate the conditions which enable a shift towards circularity in urban regions' (*REPAiR*, n.D.). In Hamburg, this programme analyses the urban patterns, including architectural and governance parameters, in five neighbourhoods, each of them having its own characteristics and constraints. With a Living Lab approach, *REPAiR* in Hamburg is a localised action research project that makes



Image of a waste treatment plant / recycling centre in Northern Germany © GIZ GmbH

it possible to establish very precise territorial diagnoses on the levers and barriers for the development of circular activities at the neighbourhood level. In doing so, local stakeholders are included in the analysis process and highlight some recommendations on how the urban layout could be modified to launch and scale up the circular management of bio-physical flows. For instance, among the challenges identified for the *Hamburg Living Labs*, *REPAiR* researchers notably highlighted the need to better integrate waste management and urban planning policies, and to act to avoid long distance between areas where waste is generated and where it is treated.

This inventory of infrastructures may also be completed with a diagnosis of urban land. While the first may highlight some specific lacks, the latter could identify potentials for new development. Urban land is indeed scarce and makes the construction of productive and logistics facilities a challenge, a fortiori with the nuisances induced. What land could be used in the urban region to host key productive functions for the circularisation of urban metabolism? Doing an inventory could highlight available surfaces, their location, and the constraints posed by the surrounding environment. For a more efficient and responsive action, such diagnosis could be subject to regular follow-up and updates. *Citydev*, a regional public company in charge of economic and real-estate development in the Brussels Capital region, does such monitoring. With a team of experts, who know well local constraints and potentials, the *Citydev* business unit holds an urban

land inventory so that *Citydev* identifies opportunities, reacts quickly to acquire land slots, and eventually develops infrastructures on it, in line with regional (circular) priorities.

Moreover, this local knowledge may inform local stakeholders on the previous affectations of land. On the one hand, it may put forward an architectural heritage which could be preserved and reused to achieve renewed productive and circular goals, as *CENTRINNO* projects do. Moreover, with a specific expertise, soil contamination may be identified and solved to develop new activities from such unused areas. In that respect, *Citydev* in Brussels works closely with the decontamination unit in *Brussels.Environment*, whose role is precisely to assess pollution, develop financing mechanisms for orphan contaminations, and accompany stakeholders in the treatment process. Among the tools developed by *Brussels.Environment*, decontamination permits are issued by their experts to establish exhaustive diagnoses of urban parcels, provide guidelines to treat them properly and estimate the costs associated with it. This collaboration led, for instance, to the development of the *Newton business park*. This SME Park was developed on a parcel of just under 38,000m². Its soil and groundwater were heavily polluted with chlorinated solvents introduced by the former battery manufacturing plant. Benefiting from European funding through the *Greenfields* program, *Citydev* had to carry out heavy clean-up operations, as outlined in the environmental permit, before the production modules could be built.

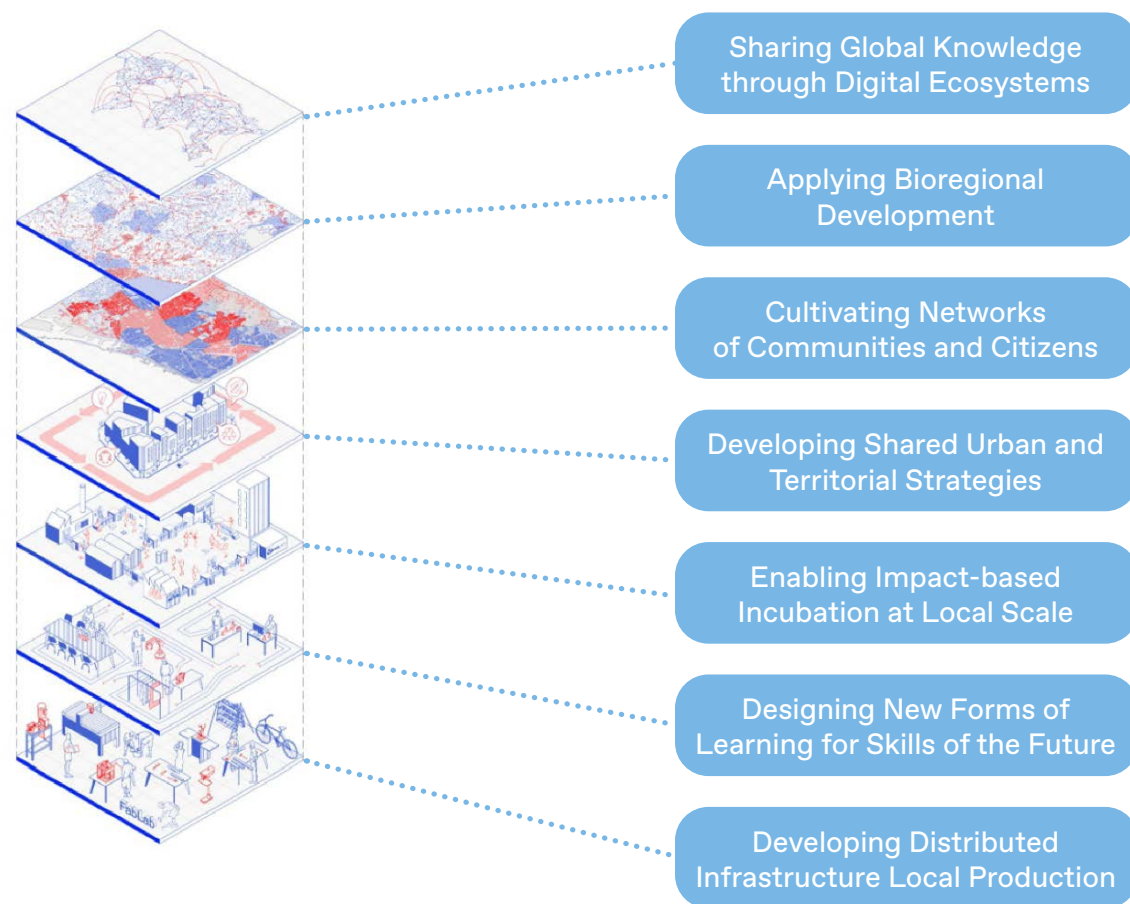


Figure: CENTRINNO 'Full Stack approach', framing cities' complex internal networks (© CENTRINNO - Creative Commons: <https://framework.centrinno.eu/centrinno-project/centrinno-and-fab-city>). Format slightly changed for better readability.

Creating useful knowledge for a local circular economy consists, we have seen, not only to highlight what bio-physical flows and stocks circulate in each territory. It also consists in identifying the productive nodes in which these are stocked and transit, and eventually transformed. In parallel, highlighting those that are lacking and identifying land opportunities for future development are as important. However, it should be noted that urban land is often under pressure and subject to speculative practices that may impede the development of such activities. Although essentials, secondary sector functions are not as profitable as others.

Palliating the limits of the market, or re-prioritising the usage value of urban land

Urban land is scarce. Consequently, maximum return on investments became the cardinal variable for functional allocation: the few land slots available must be mobilised in priority for the most lucrative operations. The four cities studied are economic hubs under demographic pressure, in which office and residential spaces are the most profitable functions per metre square. To illustrate this logic, the trajectory of the Buiksloterham district in Amsterdam North is of particular interest. In this former industrial area, alternative and sustainable activities took the 2008 crisis and the fall of real estate prices as an opportunity to settle and develop. The market has since recovered, and housing and office spaces, the most lucrative activities, are now being planned in the area (Cuomo et al. 2020). Sole market mechanisms cannot, by themselves, pave the way for a planification that is however necessary to circularise urban metabolism and develop a backdrop of productive infrastructures.

To compensate for the limits of the market, new forms of local public interventions could be envisioned to make sure that infrastructures required for the circular transition find a room in or around cities. On the one hand, regulations could limit speculative practices and control the functional allocation of urban land. On the other hand, public intervention may consist in financially and administratively accompanying businesses to settle, by helping them to access urban land and develop their activity on it. In these two dimensions, the Brussels-capital region is a particularly interesting case. To protect regional productive activities, notably around the canal area, regional authorities developed

innovative regulatory measures. Created in 2013 after an amendment to the Regional Land Use Plan, the *Zones d'Entreprises en Milieu Urbain* (ZEMU – Enterprise Zone in Urban Areas) is an operational tool for functionally mixed urban renewals. The objective of this planning measure is to create housing and amenities for the population, but also to maintain and set up productive activities and related services in mixed zones. Any operation of 10,000m² or more carried out in a ZEMU “must allocate to productive activities, to services integrated to companies, to trade or to wholesale trade a floor area which corresponds, at least, to 90% of the ground surface of the project” (Urban. Brussels, 2013). By using legal leverage, ZEMU makes it possible to temper market logics, largely favourable to housing and offices. Moreover, institutions were strengthened or created to accompany this ambition. *Citydev*, in line with its hybrid missions, proposes affordable solutions to entrepreneurs of the productive economy. While 50 years of emphyteusis could be proposed to the biggest economic players, *Citydev* also erects business parks whose premises can be rented to companies meeting the criteria established at the regional level. Such mechanisms could be replicated, and even enhanced. Criteria could, for instance, explicitly favour the development of businesses in line with circular economy objectives and leaning on bio-physical flows and needs put forward in material flow diagnoses made a priori.

In parallel to palliating the limits of the market to preserve key functions in and around the urban fabric, initiatives may also act in interstices left by real estate markets. The functional change of a land slot is a long process that could take years. This turnover opens interesting opportunities to manage urban land following a circular approach. Instead of leaving this place unoccupied, what about mobilising it to host, in a short period of time, activities not profitable enough to settle in dense areas? Rented with a low-cost price, this enables making the most of urban land and concomitantly reducing maintenance costs for the owner. In terms of transitional urban planning, *Plateau Urbain*, is a reference in the Île-de-France region. Launched in 2013, the cooperative mobilises buildings awaiting development, and proposes to entrepreneurs, NGOs, and associations to occupy it in exchange for the payment of charges and taxes. With more than fifteen active projects, *Plateau Urbain* acquired an expertise they share with decision makers in the whole Ile-de-France region and in other French cities. In the Brussels-Capital region, following the same temporary low-cost occupation logic, *Citydev* uses temporary occupation as a solution to entrepreneurs from productive sectors to install within the region. Temporary urbanism is then a flexible and inexpensive option to host start-up companies before offering them a more permanent location in rented premises or terrains. For instance, one may have in mind the trajectory of

CustomCut, which began as a start-up in the *CityGate 2* site as a temporary occupation. Today, *CustomCut* is a thriving workshop located in one of the permanent spaces rented by *Citydev*.

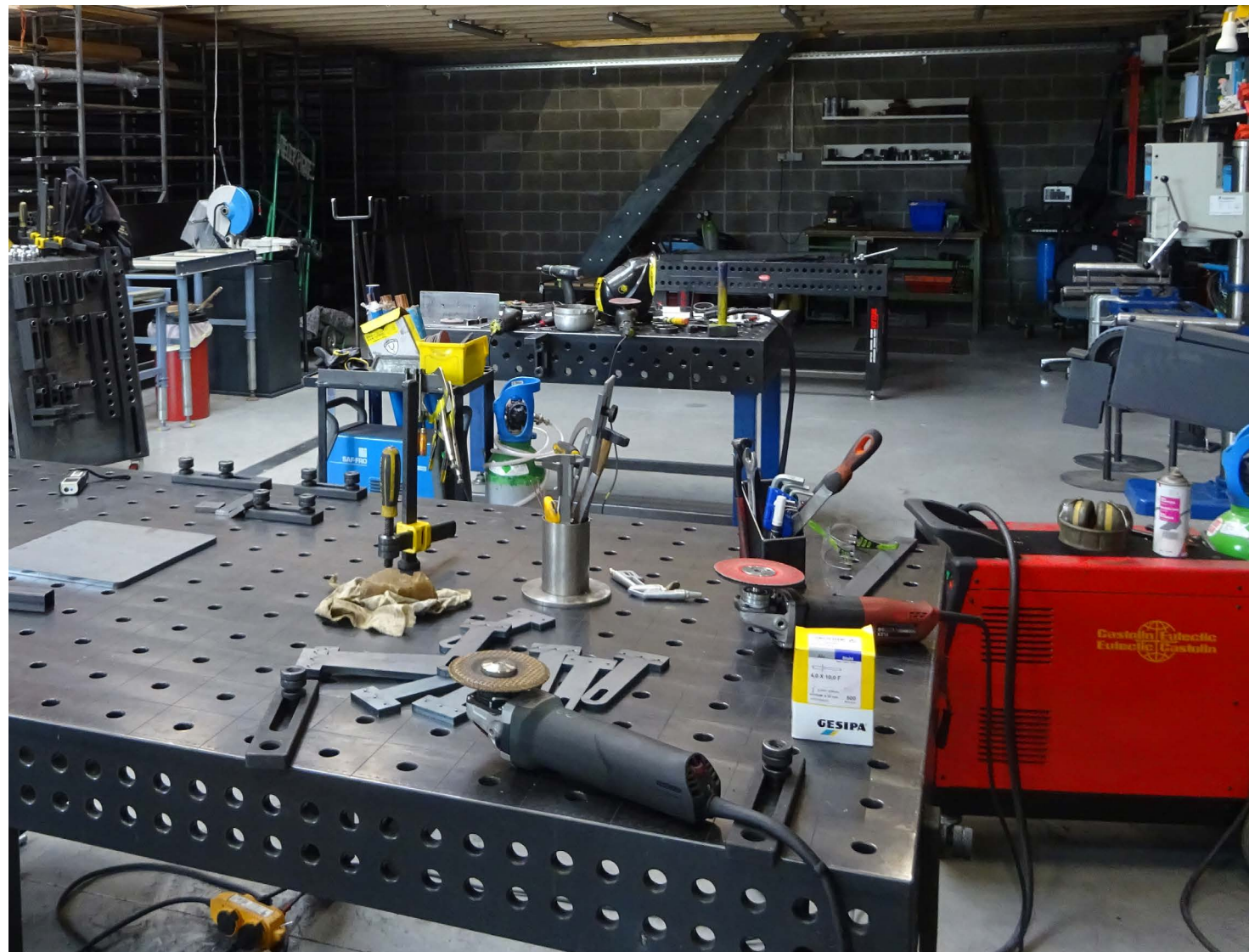
Temporary urbanism can be an adjuvant to launch pilot initiatives. While going off the beaten track with a risky activity is not easy in cities where land is scarce and expensive, the time frame between one occupation and another could precisely enable such initiatives to flourish and, who knows, have an unplanned importance for the neighbourhood. In the Buikslooterham district, in Amsterdam North, *De Ceudel* is one of the 'Living Labs' that flourished in this former industrial-port area. While green SMEs are installed, *De Ceudel* is a laboratory in which the consulting firm *Metabolic* has chosen to set up an awareness and training centre, hence creating a social hub organised following circular principles. Bio-based decontamination techniques are also being experimented and show encouraging results.

Rebalancing urban spaces in favour of infrastructures enabling the circularisation of urban metabolism requires, we have seen, innovative forms of public

interventions, and initiatives operating at the fringe of the market. However, these measures are interesting for starting-up businesses, but do not necessarily allow a long term and large-scale change. It then appears necessary to incrementally modify market orientations and definitions of what 'innovation' means in how cities are being built.



Citydev premises (© Hugo d'Assenza-David)



Citydev premises (© Hugo d'Assenza-David)

Exploring new urban forms and architectures: towards urban functions synergies

Beyond the efficient management of land, applying a circular approach to urban planning also implies modifying the way cities are built, and trigger innovation in line with circular objectives. On the one hand, such a process implies allocating land on the longest possible term. While current buildings are made to last decades, these are designed for one single purpose. In case of functional change, most of them would have to be destroyed to develop another facility, hence producing hardly valuable waste. On that point, let us note that construction and deconstruction is, by far, the economic sector that produces the most important quantity of waste. For the transition to a circular city, a paradigmatic change is required to put eco-conception at the core of urban constructions. Avenues for reflection exist. In comparing the four metropolises, we noticed that the Brussels Capital region was particularly active on these matters.

To optimise the construction of a building, reversible urbanism techniques could be mobilised. Once constructed, a reversible building is designed not only to host the function it was made for initially, but also to be able to change from one function to another thanks to the flexibility of its internal spaces. While this implies an enhanced architectural quality, with more expensive operations, it may turn on the long term, worth building. It indeed allows more flexibility over time for partial functional change, and eventually enables a quicker functional change by avoiding deconstruction and reconstruction phases. Killing two birds with one stone, reversible urbanism also gives more room for manoeuvre to incorporate specific urban functions, notably the ones structuring the productive backdrop required for the circular economy. For instance, on the *Citygate II* operation, which will concentrate housing, offices and production activities in Anderlecht, a building, adjacent to housings, will concentrate production activities on several floors and concretise vertical functional mix. In the basement, a logistics area would be connected to the upper floors by a freight elevator. For each floor, precise construction grids admit technical features to accommodate a maximum of different activities. For example, this project will have a floor bearing capacity of 1500kg/m² on the ground floor, 1000kg/m² on the upper floors, a ceiling height and column spacing sufficiently large to modulate the space or to install

machines. If the workshops do not find takers, it will be possible to convert these into housing or office spaces.

In the construction sector, there is also a growing interest in de-constructible urbanism, which posits that the current and future built environment could ultimately be recycled or reused. This first implies knowing what the city is made of. In this perspective, we already mentioned the material passport in Amsterdam. By creating transparency on the materials used, for new buildings but also for existing ones, this instrument de facto helps future operations to reuse materials. One may also have in mind the action of *Rotor*, in Brussels. In addition to its consultancy activity to encourage recycling, repair and reuse, the *Rotor* cooperative, set up, in 2016, a platform to assist building owners. The latter are trained to recover materials from deconstructed buildings, to restore them, and reintegrate them into other construction processes. Tiles, doors, furniture, porcelain furniture, porcelain, hardware, plumbing, light fixtures, planks, and sinks are then sold on the *Rotor* site, to both individuals and professionals. Beyond the clear ecological interest of such an initiative, it also has a social utility, by favouring the development of contextualised economic sectors basing their activity on the existing city. This triggers local and low-skilled jobs, not subject to industrial outsourcing practices.

Beyond materials, such an approach could be applied to newly built structures. This implies accounting for their potential reuse on the longer term during the design phase. By employing reversible techniques and robust materials, a de-constructible structure could be maintained for another function and possibly moved. Thus, the land can be made available again with a wasteless operation, which, in the end, also avoids the mobilisation of pristine resources - thanks to the re-mobilisation of the structure. Following this idea, some infrastructures for the Paris 2024 Olympics and Paralympics will be deconstructed and re-used. This is the case for the Grand Palais éphémère, a great hall of 10.000m². Located in front of the Eiffel Tower, this exhibition venue made of wood and steel was built in 2020 to temporarily replace the Grand Palais, under renovation until 2024. Events and exhibitions of the Grand Palais are now taking place in the structure before it hosts judo and wrestling, wheelchair rugby and para-judo events during the games. After 2024, the structure shall be deconstructed, and separated in five modules that would be reused elsewhere, presumably in the Parisian urban region as new sport venues.

For the development of a circular city, the notion of proximity and synergy is, we have seen, of key importance. Beyond this, in the way we organise the city, the notion of functional mix needs to be re-investigated. While the Athens charter highlighted the merits of functional separation, one district being allocated to



Building materials recovered by Rotors © Hugo d'Assenza-David

one purpose, functional mix, at the contrary, promotes the cohabitation of functions. Some reflections and innovations are left needed. On that topic, operations in the Brussels region try to innovate. On the one hand, institutions are engaged in research and development processes to develop architectural solutions to trigger vertical functional mix. For instance, the position of the *Bouwmeester Maître Architecte (BMA)* is central. Established in 2009, the *BMA* of the Brussels-Capital Region organises and coordinates architectural and urban planning experiments. This research and development process goes through the implementation of architectural competitions launched from ambitious questions, but also through the realisation of studies to produce applicable knowledge, to share feedback and to highlight demonstrators.

On the other hand, past operations proved successful in achieving horizontal functional mix. In Laeken, *Tivoli Green City* is a lighthouse project that even obtained, in 2020 and among other awards, the *BREEAM 'Outstanding'* environmental certification, 'officially making it the most sustainable district in the world'². While it hosts *Greenbizz*, an incubator for productive and sustainable companies, with spaces



Grand Palais Éphémère © Wikimedia - Creative Commons

available for rent on the same model as *Newton*, Tivoli is smartly designed to accommodate the constraints and the nuisances of each function. On the eastern side, the district is composed of housing spaces. On the western side, there is the TACT logistics platform which flows of delivery trucks constitute nuisances hardly endurable by inhabitants. In this configuration, the construction of *Greenbizz* at the core of the district not only enable to host entrepreneurs, bringing economic activity and jobs in the area: it also constitutes a buffer to isolate nuisances of the platform from housing.

Triggering a circular urban transition implies, we have seen, creating synergies to both re-structure supply chains and, by ricochet, enable some key function to

settle as close as possible from consumption hubs. Again, the circular transition of urban economies is a comeback of the material dimension at the centre of the strategic thinking. While economic performance must be measured in coherence with its biophysical impacts, the very spatial impact of these reconfigurations is not trivial, and requires innovative public interventions, architectural techniques, and urban forms. The deep changes circular economy brings also highlights the need for synergies. In the last chapter, we argue these physical transformations and interdependencies also require innovative governance and social features to establish local circular coalitions.



Functional repartition of the Tivoli Green City district, with housings ('residential blocks') and productive activities ('productive block') © Hugo d'Assenza-David. Format slightly changed for better readability.

² <https://www.offgridenergyindependence.com/articles/22351/tivoli-green-city-is-the-most-sustainable-district-in-the-world>

Shifting circular: the cornerstone of urban transition coalitions

We have seen it, the circular imperative puts at the centre the material part of the economy, through the reorientation of supply chains, and through the rapprochement of consumption and execution areas. Urban metabolism physical considerations also have a governance side. Then, it appears worth reflecting on the institutions and mechanisms mobilised at the metropolitan level which could be conducive for the reorganisation of material flows. In parallel to this biophysical update of governance objectives, urban stakeholders may also be at the forefront for the development of new common narratives to embed such circular imperative in a wider socio-ecologically transformed society perspective.

Key takeaways

- *Beyond spatial proximity, circular industrial clusters require the development of deeper social links to trigger synergies between entrepreneurs by favouring cooperative schemes on common material flows, mutualising assets and triggering the development of specific business to business circular enabling services;*
- *Instances of dialogues and cooperations beyond administrative and sectorial siloes should be favoured to take charge of material flows and interactions and establish common responses.*
- *Initiatives like trainings, incentives to orient purchase practices or physical spaces able to instigate a repair culture - like Fab Labs or Repair Cafés - are potential levers to trigger circularity following a bottom-up logic and orient consumption patterns;*
- *Vocational training should be developed in line with the circular economic sectors incubated at the local level, to position skilled workers in front of the specific needs - core or enabling activities - circular economy require;*
- *Developing a circular economy strategy requires the involvement of a large range of local entrepreneurs - including niche innovators and start-ups - in the policy-making process, beyond the sole implication of civil servants, political personnel and big economic players;*
- *As an envisioned project, shifting to a circular economy is also about providing a desirable urban future and a long term perspective to conceive urban thrive in connection with socio-environmental components.*

Connecting stakeholders: industrial circular clusters and local synergies

The shift to a circular economy would not be transformative enough if it is maintained as a cottage industry. It needs to be large-scaled, and industrial supply chains have to be modified in-depth to account for territorial, spatial and bio-physical specificities. For this, it appears necessary to establish localised industrial and circular clusters organised around this same transition goal. As we already pictured out in the first chapter, with the *Hub.Brussels* and *Isatio* initiative around textile scrap, such restructuration could be made around territorial material flows and stocks.

After the diagnosis phase, governance features composed by entrepreneurs operating at different stages of the supply chain may be further developed. Pre-existing material ties between stakeholders would then be deepened with social ties to reinforce local socio-economic ecosystems. In this perspective, the action of *Hub.Brussels* is quite inspiring. Regularly, from an arising question, bootcamps are being held with start-ups, institutional stakeholders and even citizens to discuss potential solutions and pave the way for the development of new businesses. Over time, these meetings allow not only the emergence of new ideas based on well identified problems, but also to incrementally structure thematic networks on the territory. Similarly, in Hamburg, *CIRCuiT* regularly organises circular economy hackathons to identify circular solutions across the built environment sector. For instance, in June 2021, students were tasked to create ‘a proposal for structural demonstrators (e.g. installations, prototypical component presentations) to illustrate the [circular] principles and goals of the *CIRCuiT* project in a public space [...]’ (Circuit 2022). Another interesting initiative also lies in the work *de Waag*, in Amsterdam. Located in the city centre, *de Waag* is an old institution whose history could be traced back in the XVth and XVIth centuries, when this was a defence structure and a guild hosting blacksmiths, masons, surgeons, and painters. Nowadays, *de Waag* is an unavoidable hub for makers and actors of the urban manufacturing sector, hosting training schemes, conferences and networking sessions. It also has an active role in Amsterdam urban governance, supporting the circular economy and local production initiatives in the metropolis.

This networking may also be deepened thanks to physical places welcoming businesses from similar

sectors, and, in our case, the ones concretely achieving the circular transition from existing material flows. These structures may also welcome a web of ‘circular enablers’. Key components of a circular ecosystem, these services include those that do not necessarily operate for circularising material flows, but which are fundamental for the development of any business and accompany their transition. This is one of the vocations of *Greenbizz*. While this space is specifically designed for businesses from green sectors, it also hosts jurists and other development support services. Let us note that a Fab-lab is operating onsite and financed with public subsidies; as one of the services put forward by *Greenbizz*.

On the contrary, triggering circular initiatives locally may provide a geographical proximity within thematic clusters. In structuring circular sectors, national stakeholders may establish links with local ambitions. Amsterdam, for instance, has the ambition to become a hub within the *Dutch Circular Textile Valley (DCTV)*, a sector-specific circular cluster organised at the national level. Organised around six core organisations with an expertise on circular economy matters, including *Circle Economy*, the *DCTV* organises the networking of innovative entrepreneurs in the Randstad region and carries out some lobbying activities at the national level to favour the development of circular textile businesses. Moreover, accompaniments are proposed to help initiate new businesses and help start-ups to scale up in size. These elements constitute facilities at the disposal of hosted businesses and may attract new ones.

Social ties may also be developed from existing spatial ties. While urban stakeholders all operate in a rather confined space, these do not necessarily act in coherence with their neighbours. In fact, thinking only in sectorial siloes may constitute a shortfall in earnings for businesses operating in line with the circular economy principles. Whereas it could open opportunities and collaborations, mutualising forces could avoid double-work and induce positive feedback. Following this idea, Parisian stakeholders located around the Seine River in Eastern Paris initiated the *EIT Deux Rives* initiative, a community of practice, including public actors, private organisations and associations operating in the area. They exchange, experiment and produce knowledge on circular economy topics applied to a business district. The project aims at defining an industrial and territorial ecology methodology, by experimenting with sober and productive mutualisation practices. At another scale, one may also mention the *Greater Paris Circulaire* networking platform. Sponsored by the Greater Paris metropolis, this non-physical infrastructure fosters exchanges and interactions between circular initiatives, including businesses, associations, cooperatives, and even public institutions, within the Greater Paris territory.

Members of the network are also regularly invited by public authorities to design the metropolitan circular strategy.

Beyond this, the existence of administrative boundaries from one territory to another may challenge the development of circular policies. As a material flow analysis may highlight, material and energy flows and stock are not restricted by administrative siloes. At the same time, to reach circularity, dispersed and uncoordinated initiatives may prove, not optimised at best, counterproductive at worst. Then, it seems worth developing governance schemes organised following a material-based approach, depending on the territorial bio-physical interdependencies and potentials, rather than on inherited political and administrative siloes. In the four cases studied, such an approach is rare, even if some pilot initiatives emerge here and there. In Brussels, the zone of Buda, between the Brussels Capital and Flanders regions is now thought as a future hub for the development of the circular economy in the wider Brussels urban basin. While there is a ground for furthering cooperation between businesses operating in the area, both regions cooperate in the *Circular Economy Business Innovation Zone (CEBIZ)*. In addition to upgrading the area and attracting new activities, the *CEBIZ* project objectives are clear: improve the quality of the urban environment and create favourable conditions to transition the area to a circular economy. This includes the development of common funding schemes, the establishment of new activities, but also the creation of a platform bringing together industrial partners, business services, local authorities, universities, and training organisations. Altogether, Flemish and Brussels stakeholders act in favour of the development of the circular economy in four sectors: construction, packaging industry, water and organic waste management.

In Paris, it is of particular interest to see that, even if Paris plays a pro-active role on circular economy matters since 2014, this agenda is now being pushed by the Greater Paris metropolis, composed by Paris and 130 other municipalities (for a total of more than seven million inhabitants). A similar situation could be found in Amsterdam. Even if the *gemeente* is active and has its own approach to reach 100% circularity by 2050, the Amsterdam Metropolitan Region (MRA) plays a coherence-maker role. Based on the municipalities' willingness, and on the commitment of the North-Holland and Flevoland provinces, the MRA initiates plans to trigger circular collaborations in key sectors. In 2021, for instance, MRA stakeholders agreed to launch the Wood Construction, Textile and Bicycle '*Green Deals*'. Beyond financing research and developments, the coalition of the willing agreed to launch public-private partnerships, exchange circular good practices and progressively issue circular public procurements.

Training citizen: from consumers to aware 'pro-sumers'

Shifting from a society in which a linear economy is mainstream to a circular one not only implies a modification of the production apparatus. In parallel, a cultural change modifying the whole social structure is necessary. On this matter, thinking at the urban level is, again, of relevance. We mentioned the potential of local supply chains. In addition, while most urban carbon emissions are in fact caused by the goods consumed in but produced out of the city (abroad, most of the time), there is a heuristic potential to question this mismatch and connect new circular supply chains with the local existing demand. Private or semi-private initiatives may, for instance, incentivise buyers by promoting a local manufacturing culture. For instance, in 2015, a cooperative of entrepreneurs launched the *Amsterdam Made* label. In addition to the networking opportunities it opens to local SMEs from the manufacturing sector, this label gives visibility to locally produced goods and allows them, in a way, to be branded for their quality and local commitment.

Beyond a modification of consumption practices, another lever for a circular transition consists in instigating a repair culture among citizens. Without necessarily having drastic restriction, reducing consumption from a circular perspective implies reducing lifestyles' material consumption. Thus, when something is broken, it is about changing people's reflexes: instead of throwing it away, isn't there a way to repair it? Even if the cultural and education dimensions are at the core, and seem hardly modifiable at the local level, having the infrastructures, the tools and the skills right next door to accompany this change may be adjuvants. Will citizens be more likely to have things repaired if they have the infrastructure less than fifteen minutes away from their place? In the cities studied, institutions accompany the transition from a consumption culture to a repair one. How not to mention Repair Cafés? Launched in Amsterdam in 2009 by Martine Postma, Repair Cafés are meeting places in which technicians volunteer some time out of their day to help repair broken objects brought by inhabitants of the neighbourhood. Since 2009, the network has expanded: located in fifteen countries, there are now more than 2000 Repair Cafés in total. Similarly, one may have in mind makerspaces, and notably Fab Labs, small cooperative workshops that offer training, and provide an access to machine tools and digital fabrication apparatus - including laser cutters, wood saws or even 3D

printers. Such small-scaled infrastructures are present in the four metropolises we scrutinised. In Brussels, the region finances three Fab Labs in *Citydev* facilities. The *Cityfab*'s public financing model and regional ambitions are quite unique. Beyond being services for businesses to prototype and eventually test new production processes at a minimum cost, FabLab may be social and training spaces. For instance, *Cityfab 1* has been conceived as an open space in which individuals can be trained to specific techniques (including laser cut, woodcutting, 3D printing...) and could use the machine-tools with a variable package according to their needs.

In addition, beyond empowering citizens, from customers to aware 'pro-sumers' (Savini, 2019), having the workers with the right skills in front of each sectoral need is crucial. In this respect, developing training schemes in line with necessities and existing initiatives may be a critical component of a local circular strategy. This also kills two birds with one stone: beyond the circular objective, such a measure also brings socio-economic benefits by offering job perspectives to a local workforce in connection with economic ecosystems. In Paris, the municipality is financing and organising circular training schemes with the *ParisFabrik* programme, a call for projects that aims to support structures and players in the circular economy, in setting up training courses in emerging trades and sectors. Training structures could benefit from public subsidies not only to invest on training

schemes, but also to help finance their functioning costs. With this programme, Paris also supports open training schemes, including MOOCs, to trigger the qualification of Parisians in strategic sectors in line with circular objectives.

Private and civil society actors may also be adjuvants for the structuration of training schemes. For instance, the *Fab Lab Fabulous St. Pauli* offers to 'all creative minds' the opportunity to come up with their ideas and get advice in the incubator's weekly consultation hours. Also, Amsterdam, Paris and Hamburg are parts of the *Fab City Global* initiative. Initiated in 2014 in Barcelona, this global challenge defies cities to produce as much as they consume by 2054. Local Fab City networks - composed mainly by makers - carry out pilots and are lobbying in favour of local distributed manufacturing training schemes. In this respect, it is worth having in mind the *Master in Design for Distributed Innovation (MDDI)*, offered by the *Fab City Global foundation*. Combining online and hands-on learning, the MDDI supports the development of social and technical skills needed to develop circular productive projects. This decentralised study program is composed of online seminars, activities with local research groups, and the production of physical prototypes in Fab Labs. With those yet small-scale initiatives, Fab Cities are figureheads for an alternative urban future in which circular economy is the cornerstone.



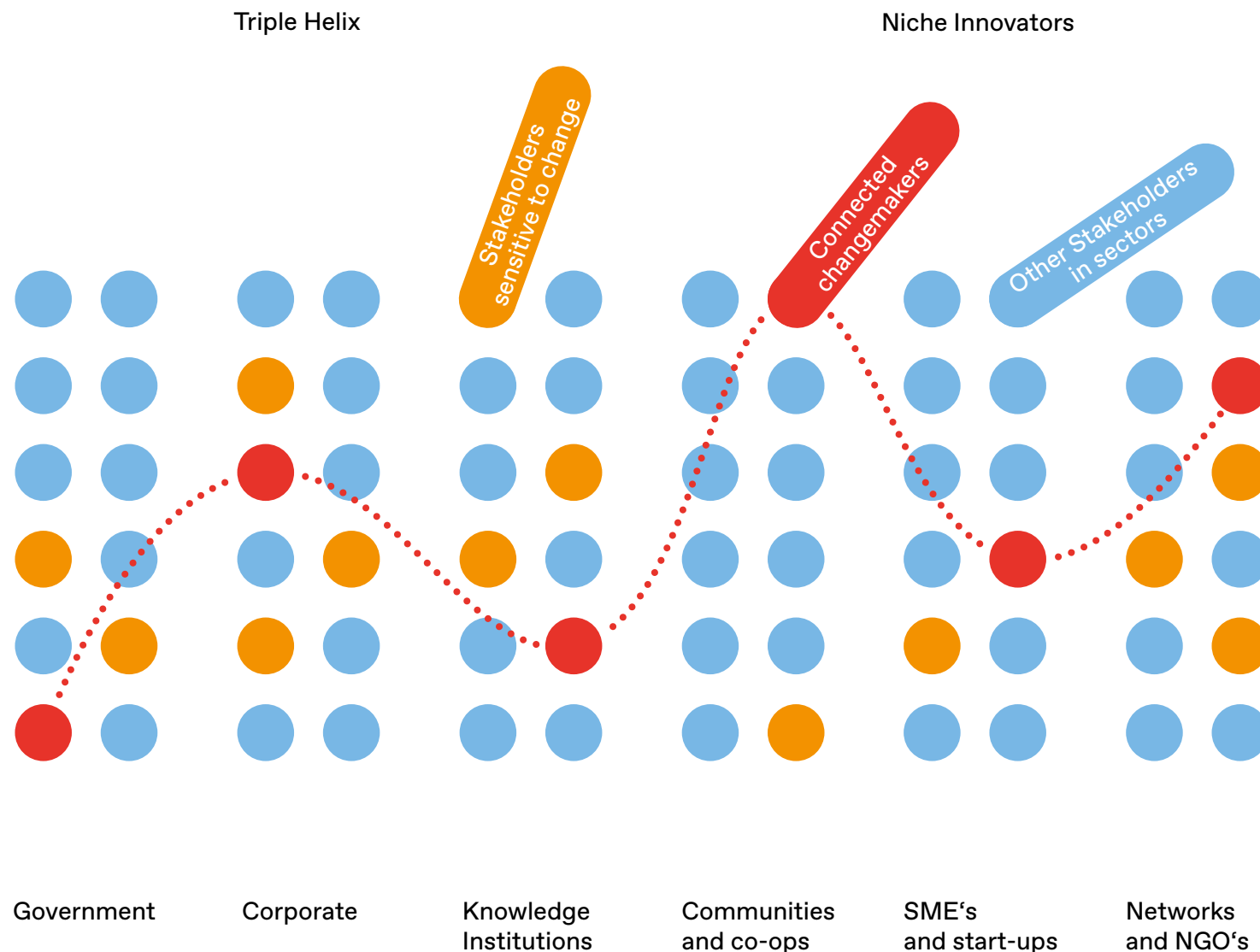
ParisFabrik (@LaPatiteRockette - ParisFabrik)

Projecting urban governance in longer-term circular urban future

Beyond the battery of measures and infrastructures we mentioned to favour a circular economy, the shift away from an 'extract-throw-waste' society may also be triggered by encompassing all of these within a wider common narrative. On the one hand, while policymaking is often a relatively closed process with a

few players – including, in most configurations, representatives, biggest economic players and experts – there is a great potential in expanding these governance features.

Within urban governance, decision-making venues are contextualised. Then, it is easier to identify and include NGOs, SMEs but also civil society organisations operating locally. While they also have territorial expertise and may provide relevant insights and feedback from the field, they may also be keener to innovate and find new pathways in response to the economic and socio-ecological transition challenges. Moreover, these stakeholders may constitute a transmission belt between the policy making process and its application but could also favour a more reflexive policymaking by triggering back and forth. In this respect, to develop their 2020 circular economy strategy, the municipality of Amsterdam relied on a 'double-triple helix'. From an initial 'triple-helix'



policymaking process composed by major economic players, elected representatives and researchers, the policy process behind this new strategy has been opened to local NGOs, SME and start-ups, but also to local cooperatives. By doing so, local representatives both expanded their support base, and acquired a non-usual and innovative expertise.

Paving the way for an alternative circular urban future is about projecting a desirable perspective, to highlight, on the longer-term, the transformative potential of circularity. For now, shifting circular is yet an envisioned project with competing perspectives on how to concretely achieve it. The horizon is settled, priority must now be given to find concrete and contextualised paths to move forward and mobilise stakeholders' energy in this same direction. One may, for instance, be inspired by maker communities. As a new kind of entrepreneurs which base their action on open data and sharing economy principles, these are changemakers that pave the way for alternative modes of production and consumption (Berrebi-Hoffmann et al., 2018). We mentioned the *Cityfab* network, and the means of production pooling by the *Microfactory* initiative. Beyond Fab Labs and small-scale industries, it is worth having in mind how they collectively mobilise to challenge current linear supply chains. Makers are, for instance, central in the *Fab City Global* initiative. Beyond this wishful thinking, the *Fab City* network networks localised networks. In each *Fab City* initiative, stakeholders are organised around this goal, settle experiments and try to stimulate the development of new embedded circular supply chains. While most of these are principally composed by universities, grass-root activists and maker-based initiatives, these could undoubtedly contribute to the constitution of more holistic narrative and political projects to embody the circular imperative in urban territories. In Hamburg, this networking potential is put forward by the *Interfacer* pilot project. This collaborative and freely accessible platform aims to establish a 'data-based' circular economy and allows each contributor to put patterns online in open-source, so that everyone can seize them and apply them in a local context. This meta-infrastructure then avoids double work and favour interactions in a multilevel perspective.

While each circular approach is politically marked and enshrined, the physical imperative to shift away from linear modes of production and consumption opens a beneficial Pandora's box to question and perhaps redefine collectively the very notion of prosperity. While this could (should?) be done at different levels, urban governance has an opportunity to make a difference. Cities are a mezzo-level where the consequences of the policies developed, and their co-benefits, could be directly observed, and even felt on the field. Along this study, it was of particular interest to see that, among the cities studied, three of them (Brussels, Hamburg

and Amsterdam) have local coalitions composed of stakeholders that push for the application of Kate Raworth's *Doughnut Theory*. Based on her best seller *Doughnut Economics: Seven Ways to Think Like a 21st-Century*, this British economist considers GDP growth as an outdated indicator to measure the economic performance of a given entity, may it be a state, a company or a city. She argues that, instead, human thrive should take place within the limits of a doughnut. While it must not exceed planetary boundaries, it should, at the same time, ensure a social minimum to enable each person to grow and thrive equally. Even if this remains broad and subject to different interpretations, Raworth's observation makes sense: it launched local reflections on what it means to thrive in the cities concerned, and what measures should be taken. While, in Hamburg, the *Doughnut local coalition* is still in the structuration phase, policymakers and elected representatives in the Brussels-Capital region are now reflecting on how to concretely apply this theory into policies.

In Amsterdam - an urban laboratory for the Raworth's *Doughnut Economics Action Lab* (DEAL) - the doughnut theory has been put at the core of the sustainability agenda and structures the circular strategy since 2020. Circular economy is one of the pillars of a wider urban transformation project, putting a possibility for the development of business models in accordance with the planetary boundaries. First feedbacks are emerging, and policies are being developed to increase the concretisation of *Doughnut* principles. For instance, the *Amsterdam Monitor*, which is pushed by the *Chief Technical Officer* team, consists in creating policy instruments and indicators to provide a 'continuous insight into the ecological ceiling and the social foundations of Amsterdam's economy' (Municipality of Amsterdam, 2020a, p.84). While the *Amsterdam Doughnut* enabled more local and small-scaled initiatives to embed in the circular economy local agenda, forthcoming reflections would focus on the development of new localised indicators to measure precisely and intelligibly collective and individual socio-ecological performances.

As spatial entities, cities materialise the matching between social, economic and ecological components. These are a privileged observation post to assess the impact of institutional, political, architectural but also economic innovations. This reflexive capacity appears key to respond to rising resilience and environmental challenges by concomitantly considering local identities and heritage, with which the circular transition would have to deal with. Although challenges are global, the consistency of the responses would rely on their capacity to compose with context-specific situations and stakeholders to mobilise transition coalitions.

Conclusion

This research consisted in a comparative analysis, highlighting contextualised exemplary policies and infrastructures to initiate and scale up the circular transition. To put forward common trends and challenges, the reflection was organised following three perspectives, or three aspects to have in mind when considering the circular city. First, and quite obviously, thinking about the circular economy is about considering it as a hub for biophysical flows: shifting circular is here a process of material flows rationalisation, reorienting socio-economic activities, and the related infrastructures, in line with urban metabolism needs and characteristics. Then, conceiving the circular city is about considering it as a physical space under constraints, in which room should be maintained and preserved for infrastructures, including material banks, repair workshops, recycling facilities but also logistics hubs. This is a great challenge posed to urban planning and to the construction and deconstruction sector. To conjugate these emerging yet vital needs with existing pressure, planning and architectural innovation may indeed be mobilised to trigger mixed uses and synergies between urban functions. Thirdly, the circular city is a specific level of governance, composed by local actors with sectorial logics and constraints. However conflictual policy development could be, the city also constitutes a theatre of cooperation between those, providing a common ground to settle the required urban transition coalitions to achieve the circular imperative. These perspectives are not impermeable to one another: remaining gaps and challenges are at their crossroads.

Along this study, similar barriers and challenges were identified and put forward as key points of improvement. Whatever the context is, in Europe and beyond, these constitute policy and innovation priorities for public stakeholders, economic players and other game changers.

- **Contextualising and opening data**
Disposing of relevant data to identify and quantify resources - may it be biophysical materials or land - is of key importance to trigger a circular transition. While contextualised knowledge permits a better identification of local characteristics, open knowledge allows each one to seize it and to structure new sectors. These two dimensions ultimately enable the development of on-the-ground innovative initiatives to respond to needs and unleash context-specific potentials.
- **Prioritising the usage value of space and infrastructures**
The circular imperative requires specific physical assets to manipulate and rationalise biophysical material flows. While progressively reorienting existing ones in connection with urban metabolism needs and constraints could be a target, new ones might be developed. In this context, while residential urban functions are often favoured in the speculative trade-offs for the allocation of constrained urban land, it seems central to valorise the land in relation to the potential uses it may host. Instead of blindly assigning it an exchange value, putting forward its usage value may facilitate its preservation to key functions for urban metabolism.
- **Bridging the knowledge and training gaps**
Taking the plunge towards a circular future is about fighting against misconceptions, presenting what circularity is, highlighting what it implies and putting forward what practices are exemplary. This is also about bringing to the fore potentials associated with it, including jobs or collective co-benefits for a given territory. In this respect, developing targeted training, and making connections with research and development institutions, can accelerate the development of territorial skills and innovative clusters. The structuring of incubators shows new business models capable of adapting to this new socio-economic situation, and able to inspire whole sectors.
- **Creating confidence**
In coherence with the previous point, the shift to a circular economy also requests the creation of an atmosphere of confidence towards this yet envisioned future. Market actors, to initiate and fully

embrace this perspective need to be provided with long term prospects and guarantees. With the creation of norms, the establishment of circular terms of reference, by developing new financing schemes, or by erecting new physical infrastructures, public actors may be the cornerstone of this bolster dynamic.

- **Breaking walls between siloes**
The circular shift, by its dimension and its implications, requires overlaps between sectors and administrative boundaries. Whereas reasoning in terms of biophysical material flows based synergies blows up those frames of reference, there is also a potential in including new stakeholders and pave the way for a more integrated cooperation between thoughts that do not tend to intersect.

A key idea lies behind the circular transition: act locally, think holistically. While the three dimensions of the circular city we mentioned should be considered in coherence with one another, the urban standpoint is a proper one to consider and act on them concomitantly. Local public action is perceptible, where it could trigger ricochet co-benefits and bridges the mismatch between economic imperatives and socio-economic ones. Cities and local stakeholders then need enough room for manoeuvre to contextualise their action with, at the same time, integrating grounded developments with higher levels of governance.

Beyond scales, the relationship between actors' perimeter is questioned by the circular imperative. In shifting circular, public authorities have a great opportunity to redefine their structuring role towards markets. While economic players have to be embarked into transitioning trajectories, sole markets are limited in their capacity to transition. As we have seen, they prove, at the moment, to be insufficient to respond to the biophysical and social logics the circular economy imposes.

Public governments could help leveraging such transition by palliating the limits of the markets and operating in its interstices, regulating excesses and limiting practices contradictory to the circular economy. Moreover, they may play a more interventionist role to impulse transformations and create new commons. While physical and non-physical infrastructures could be financed, constituting the hard and soft wares to operate socio-economic changes, meta-infrastructures, such as open data sets and depository, could be created and hosted by them.

The magnitude of the circular transition should not be underestimated. It cannot just be a story of craft and small-scale development: to address the vital challenges in front of us, it needs to be massive, requiring a political reorganisation, and a modification of what it means to innovate. Development processes have to make back and forth movements between the needs and prospect outlooks.

This report focused on European cities relatively advanced in this circular transition. This analysis may also inspire Global South stakeholders who could be confronted with more flexible, emerging policy and infrastructural developments. These situations may also admit a more important room for manoeuvre for bottom-up and innovative dynamics in line with the ecological transition and, by ricochet, even take the lead on some key circular economy aspects.

Where are we? Circular economy is yet an envisioned future highlighting the importance to connect anthropic development with biophysical considerations. Overall, we have seen it, it requires a new perspective for collective action, a new global vision on how we streamline economic activities, infrastructures and public policies. As the analysis of cities and urban metabolism suggests, the shift towards a new socio-ecological regime is required. Shifting circular constitutes a great potential to trigger renewed symbioses and modern modalities for the operation of urban coalitions. Whatever the context is, similar challenges and common questions remain to be addressed. Among those, the definition of a 21st century collective vision is surely the most prominent.

What does it mean to collectively thrive in a resource-finite world? Where do we want to go?

The future is in our hands, and let us consider cities at their fair value, as scouts in this transitioning world.

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Technical sheets

Madaster: a standardised material passport

Based in Laren, in the South-East Amsterdam periphery, *Madaster* operates in the construction industry. Its material passport informs, for each building documented, its location, the materials used for its construction and their quality, the processes mobilised, as well as recommendations to reuse and recycle it. The agglomeration of such data enables the creation of a biophysical cadastre, a key database informing on the material composition of cities: it enables the identification of existing and consistent material stocks within the city, that could ultimately be reused in future urban projects. In the *Madaster* case, this repository is accessible via a professional licence or a private subscription.

In the Amsterdam Metropolitan area, *Madaster* works in close cooperation with public authorities to pilot and mainstream the issuance of material passports. In 2020, five municipalities received a Material Passport Certificate, as part of the material passport pilot project, after having documented the biophysical cadastre of public facilities. This then enables a traceability of the built environment. What is in there? How could these biophysical stocks be mobilised? Disposing of such data is of key interest for the structuration of circular deconstruction, construction and refurbishment industries. While this may constitute a source of inspiration to develop new businesses, using common frameworks and constituting localised datasets are key meta-infrastructures to assess the material side of the city, and making the most of it in triggering policy and economic circular innovation.

The *Madaster*'s innovative action may inspire other economic players, but also public authorities. Given the strategic economic importance of such biophysical data, the establishment of secure, accurate, and complete open data platforms hosted by public entities, whether local governments or not, appears to be of public interest in the context of a circular transition.

Website: <https://madaster.nl/en>
Contact: info@madaster.nl

CENTRINNO: from local diagnoses to local productive transformations

CENTRINNO (*New CENTRAlities in INdustrial areas as engines for innovation and urban transformation*) is a European H2020 project launched in May 2021. Over a period of four years, its objective is to highlight the heritage value of industrial brownfields and to promote more inclusive and sustainable urban production models. The project thus proposes the revalorization of historical industrial sites into “creative” and “inclusive” hubs, ‘producing locally’ (*CENTRINNO* 2021). *CENTRINNO* is thus spearheading innovation towards the establishment of productive cities, “Fab Cities”, by placing citizens at the heart of the transformation of industrial sites and the deployment of new local and circular production chains.

Embedded in this new industrial paradigm, the project focuses on five pillars developed with specific methodologies and tools: circularity, legacy, professional training, social inclusion and “Fab City Hub”. Beyond accompanying the revalorization of former industrial spaces, the program aims to establish contextualised knowledge by setting up simultaneous research-action initiatives. This involves the use of cartographic tools, *Material Flow Analysis*, and questionnaires to key actors. The characterization and localization of waste flows, as well as a detailed understanding of the interactions and practices of actors, will make it possible to identify specific demands and resource flows that can be mobilised to structure local value chains.

Supported by the municipality of Milan, *CENTRINNO* networks initiatives in eight other European cities: Amsterdam, Paris, Geneva, Copenhagen, Barcelona, Tallinn, Blönduòs and Zagreb. Although interconnected, pilot projects are complementary and allow for approaches specific to the ecosystem in which they take place. By the actions undertaken, *CENTRINNO* projects are of key interest for a circular transition: while new indicators are developed and local diagnoses established, these are put in coherence with local productive ecosystems to help them transition into another circular perspective.

Website: <https://centrinnoeu>
Contact: info@centrinno.eu
Expert: Pietro Lupo Verga — City of Milan
Project Manager *CENTRINNO*
pietrolupo.verga@comune.milano.it

ParisFabrik: a funding scheme to constitute a pool of circular-skilled workers

ParisFabrik is a funding program initiated by the municipality of Paris in 2017 to trigger the development training schemes in line with urban transitioning objectives. As part of the Attractiveness and Employment direction, *ParisFabrik* aims at favouring the emergence of a sustainable and circular city following a bottom-up approach. By encouraging the development of specific skills, new activities can emerge from these trained potential entrepreneurs, and the stakeholders already structuring circular economy related sectors in the city can draw from a bigger and bigger pool of skilled workers. Moreover, this program bridges the circular imperative with social inclusion objectives, by establishing training schemes from contextual needs and by triggering transitioning dynamics.

Training organisations and professionals supported by the programme are being selected for their ability to present innovative responses to the employment and training issues in emerging or shortage sectors that offer job opportunities. Among those, the municipality identified ‘Reuse, prototyping and urban manufacturing’, ‘Circular economy, eco-conception and functionality economy’, ‘Construction and eco-refurbishment’, but also ‘New mobilities’ as strategic priorities. Each year, calls for proposals are updated depending on the needs identified on the ground, and a catalogue of training supported by the city is made available. These are not necessarily located in Paris, but must be accessible to Parisian citizens who can apply to it. Each year, between 250 and 400 people are trained in *ParisFabrik* training courses to obtain qualifications and certifications enabling them to enter the job market, providing additional skills, particularly in the area of reuse and repair.

In a second time, once the training is completed, connections are being made with potential employers. This year, for the first time, *ParisFabrik* has set up specific training courses based on the needs of entrepreneurs. From specific job offers, courses are organised to train workers so that they can position themselves on these job offers in the future. For example, a training course to work in the heavy household appliances repair industry has been set up with local companies.

Website: <https://www.paris.fr/pages/se-former-aux-metiers-du-reemploi-et-de-l-economie-circulaire-avec-parisfabrik-6007>
Contact: dae-parisfabrik@paris.fr
Expert: Ondine Demblocque — City of Paris
Professional training projects manager
ondine.demblocque@paris.fr

Interfacer: an online platform to openly share models and practices

Launched in the context of the Hamburg *Fab City* Initiative in September 2022, *Interfacer* is a pilot project that aims at developing a digital platform at the destination of public authorities, designers and producers, but also to individuals, to share data, source code, models of production as well as know-how. From the concept of commons-based peer production, this 'Fab City Operating System' (OS) would ultimately gather knowledge and practices. This open-source repository is being pushed by a consortium of public and private actors, including the *Helmut Schmidt University*, the *Dyne foundation* and the *Hamburg Institute of Value Creation Systematics and Knowledge Management* (HIWW).

Interfacer fills a gap by providing a digital infrastructure designed to enable a data-based circular economy that, at the same time, connects local and global scale to trigger alternative modes of production connected with needs. Such an open access platform enables the mutualisation of research and development activities and the reduction of associated costs. In providing easy access to models for specific good production, this database enhances the transformative power of machine tools by putting forward a wide diversity of objects to be manufactured quickly, without any design process.

From the same idea, the sharing of reproducible models was key during the Covid-19 crisis, with personal protective equipment that were produced in a record time by Fab Labs and makers. Couldn't we imagine such models to be pre-established before crises, so that objects and equipment in need could be manufactured quickly? In a context of supply chain uncertainty and resource shortage, crisis preparedness is not only about making preventive stocks, it is also about quick and evolutive collective reaction.

Website: <https://www.interfacerproject.eu>
 Contact: interfacerproject@hsu-hh.de
 Expert: Wolf Kuehr — Interfacer
 Lead Communication & International Collaboration
wolf@fabcity.hamburg

Citydev.Brussels: a hybrid innovative institution to trigger functional mixed-use

Citydev is an innovative public authority which combines a role of economic development and real estate developer. It was initially launched in the 1980's to maintain and bring back productive activities in the Brussels urban capital region. At the time, in the image of many Western cities, Brussels suffered from deindustrialisation and many activities were transferred out of the region. This trend was accentuated later on with the growing importance of European institutions that brought tertiary economic activities in the city, for which workers were living out of the regional boundaries.

Citydev was launched to acquire land in the region and develop productive functions on it. To face speculative and demographic pressures and in coherence with its initial target, *Citydev* incrementally moved towards research and development missions to trigger architectural and urban planning innovation. With public funding, the infrastructures erected by *Citydev* are being designed to preserve key and socially inclusive urban functions for Brussels in parallel with office and housing spaces. In doing so, *Citydev* highlights proof of concept as levers of change in the construction sector showing the techniques to use and putting forward how viable such combined urban developments are. While the development of a vertical functional mix has already proved its worth, notably in the Tivoli district, current projects aim to implement a vertical functional mix. In a second time, once facilities are built, specific companies are selected to settle at a relatively low cost and trigger synergies with the existing actors. In the more recent period, *Citydev* has made some changes to fit into new dynamics. While its historic missions fit well with the circular priorities of the Brussels capital region, highlighting the need for productive activities and the development of new circular supply chains, new services are being proposed to entrepreneurs including the access to *Cityfab's* network Fab Labs or temporary occupation leasing contracts, like in the *Citygate II* project.

With its action, *Citydev* is an institution that may play a central role in the development of a circular economy. By developing mixed-used physical spaces and triggering urban planning innovations, this hybrid actor may leverage the circular transition by acting on the 'hardware' infrastructures required for a circular transition.

Website: <https://www.citydev.brussels/en>
 Contact: communication@citydev.brussels
 Expert: Laurie Verheyen — citydev.brussels
 Circular economy strategy coordinator
lverheyen@citydev.brussels

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About the author

Hugo d'Assenza-David works at *Sciences Po* as a PhD researcher in comparative politics, at the crossroads between urban studies and public policy analysis. With the support of the *French Agency for the Ecological Transition (ADEME)*, the *Plan Urbanisme Construction Architecture (PUCA – DGALN)* and the *Greater Paris Metropolis*, Hugo leads a reflection on the development of material flow accounting policy instruments. Based on a comparison between three metropolises, he reflects on how such tools shape local policy agenda setting, and how urban governance evolves with this increased attention given to the material part of economies. In a context of increased attention paid to circular supply chains, and a comeback of strategic economic planning, Hugo d'Assenza-David reflects on the impacts these new considerations have on the activities of urban productive infrastructures, and their development.

