

**CIRCULAR  
CITIESHUB**

## CIRCULAR CITIES: STRATEGIES, CHALLENGES AND KNOWLEDGE GAPS

A Summary Report of  
the Expert Workshop -  
September 2016

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### **About Circular City Hub**

The Circular City Hub brings together international academics, practitioners and policy-makers working in fields relevant to the design, implementation, governance and management of circular cities. It provides the interface between academics and key urban stakeholders, enabling cutting-edge research to impact directly on the delivery of circular cities. The Hub works in association with the Ellen MacArthur Foundation.

For more information on the Hub please visit: [circularcitieshub.com](http://circularcitieshub.com)

Updates regarding the Hub and its activities will be posted on this website as well on the 'Circular Cities Research Hub' group on LinkedIn and Twitter account (@CircularCities).

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## Executive summary

This document reports on the key discussions and conclusions of the inaugural workshop on circular cities organised by the Circular Cities Hub. The workshop was held in London on 26 September 2016, sponsored by UCL Grand Challenges and in association with the Ellen MacArthur Foundation. It brought together academics, consultants, policy-makers and think-tanks to develop an understanding of the circular city concept and challenges to implementation. The workshop was centred on three themes: strategies for delivering circular cities; challenges to the transformation to circular cities; and knowledge gaps.

## Strategies

The principal goal of adopting a circular approach within city-regions is to reduce resource consumption and waste production. It is also to ensure the long-term sustainability of the city-regions natural ecosystem and urban infrastructure. The resources affected by this approach include land, energy and water as well as materials (goods, infrastructure and materials). In a circular city resource flows are cyclical and localised through closed-loop, integrated systems, often resulting in reduced resource consumption, waste and CO<sub>2</sub> production (**looping, localisation and optimisation**). The built fabric is adaptable, flexible and recyclable (**adaptation**). Resources are re-used, recycled, recovered (**looping**) and shared (**sharing**). Renewable energy makes a significant contribution to the energy mix and there is a shift towards non-resource based economies (**substitution**). The urban living environment adapts to people's needs throughout the life-cycle, also evolving with cultural and demographic changes (**adaptation**). Natural capital is restored and regenerated. Ecosystem services actively support, regulate environmental processes and produce new resources within the city-region (**regenerate**). Thus, seven circular strategies - looping, localisation, substitution, adaptation, sharing, optimising and regenerating natural capital – operate together to deliver the circular city-region. The emphasis placed on each strategy will vary with local context and policy priorities. This report explores a variety of circular strategies adopted in six European cities (London, Bristol, Peterborough, Amsterdam, Stockholm and Paris) and the experiments which have emerged from application.

## **Challenges**

The key challenges to the delivery of circular cities are cultural, economic, political, regulatory, institutional, physical and informational. The analysis suggests that institutional and economic challenges are likely to create the greatest barriers to a circular transformation, followed by regulatory and political challenges. However the challenges identified varied across the seven strategies. The inflexibility of institutions; their lack of engagement with civil society, and the involvement of global institutions in local service delivery are seen as major challenges to the successful circular transformation. The restructuring of the macro-economy and shift in cultural values required to deliver circular cities creates enormous inertia to change. Inadequate political leadership, the erosion of municipal competencies and resources also challenge local implementation. A lack of supportive regulatory framework creates a real problem in aligning actor goals to deliver the circular cities agenda. The inflexibility of urban infrastructure and the technological lock-in this creates, presents a challenge for implementing all circular strategies. Finally a lack of useful data for monitoring resource flows; monitoring the impact of policy instruments and regulatory frameworks; and for changing actor behaviour also makes implementation problematic.

## **Knowledge Gaps**

The knowledge gaps affecting delivery of circular cities were discussed at the workshop. Four themes emerged around definition, strategies, motivation and implementation. The first group of questions focussed on the definition of a circular city, its goals and philosophical underpinning. The second questioned how circular strategies might fit together. There were obvious overlaps between strategies, generating potential conflicts and synergies. These relationships require further investigation. The third group of questions focussed on the potential motivations for adopting a circular approach in cities. This required a more detailed assessment of the economic, social and environmental advantages / disadvantages of adopting the approach and detailed consideration of how it might be used to solve contemporary urban problems. The fourth group of questions explored the challenges to successful implementation of circular strategies which had been highlighted in the previous session.



## 1. Introduction

This document reports on the 'Circular Cities' workshop held at the Urban Innovation Centre in London on 26 September 2016 organised by the Circular Cities Hub, sponsored by UCL Grand Challenges and in association with the Ellen MacArthur Foundation. Presentations and information on city and academic projects on circular cities presented during the workshop are available on the Circular Cities Hub website: <http://circularcitieshub.com/>. This report presents the discussions and conclusions of the workshop.

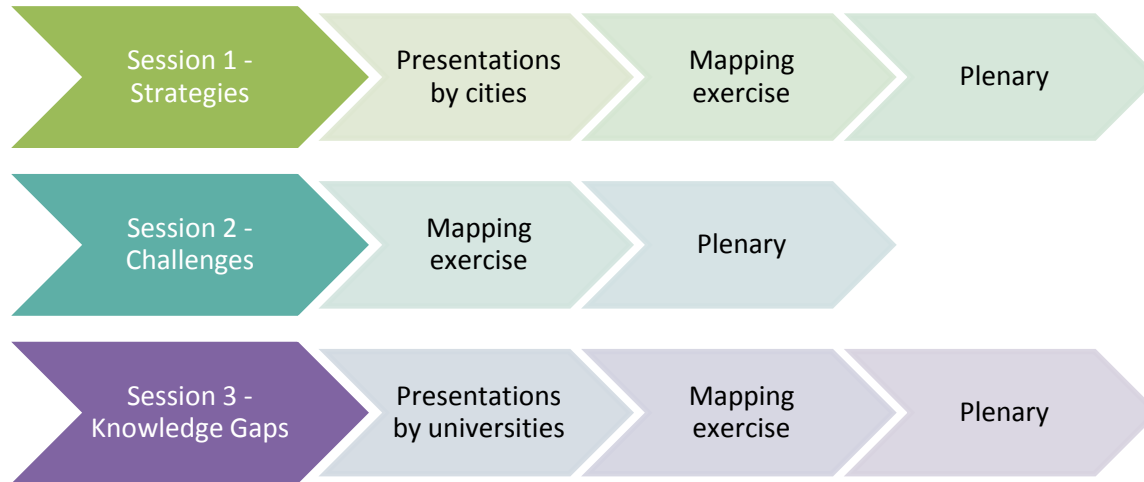
The workshop explored 3 questions:

- *Strategies*: What the strategies can be deployed to deliver a circular city?
- *Challenges*: What are the challenges to circular urban transformations?
- *Knowledge gaps*: What are the knowledge gaps that need to be addressed in order for the transformation to be successful?

### 1.1 Workshop format

Each of the questions were explored using a mix of formats: presentations, small group mapping exercises and plenaries (see Figure 1 and Annex B for a more detailed workshop agenda).

Figure 1 Workshop format

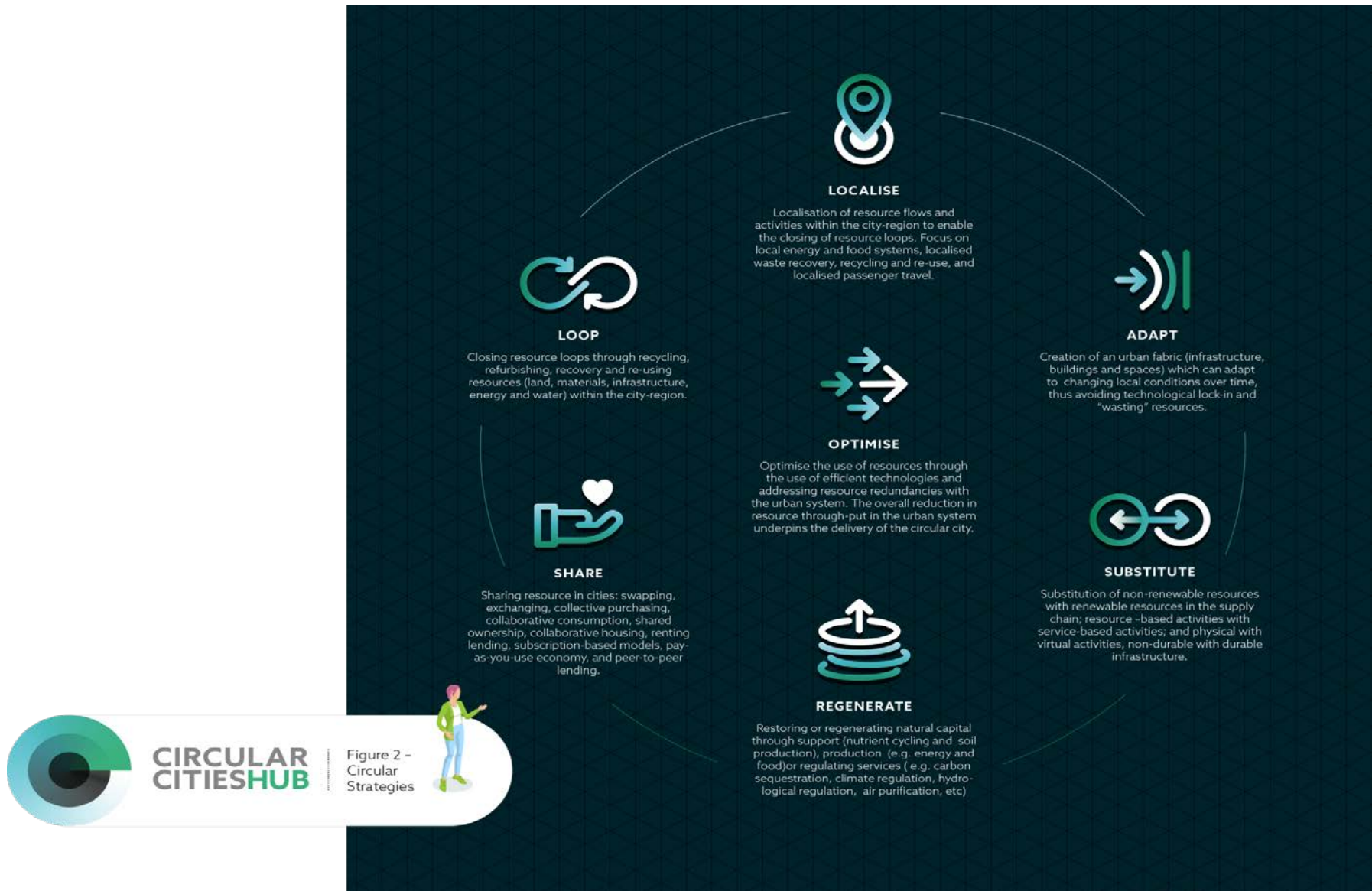


The presentations provided context to stimulate discussion. In the first session, a variety of circular strategies were presented by representatives from the cities of Amsterdam, Bristol, London, Paris, Peterborough and Stockholm. The strategies were diverse focussing on resource sharing, looping, localisation, substitution, adaptation and ecological regeneration. The links to the cities strategies can be found in Annex C. In the third session, leading European academic institutions – Delft University of Technology, HafenCity University Hamburg, KTH Royal Institute of Technology in Stockholm, Lund University, and University College London – presented their current research on circular economy, sharing economy, resilient cities, circular infrastructural and planning models. These presentations helped to begin to highlight the knowledge gaps surrounding circular urban transformations.

There were three mapping exercises: strategies, challenges and knowledge gaps. The workshop participants (60 in total) divided into five focus groups (12 participants per group). These groups consisted of experts from academia, think-tanks, consultancies, government and business. The groups focussed on five circular strategies: resource localisation; looping (recycling, reuse and recovery); substitution; sharing; and adaptation. Two additional strategies were added to the list after the workshop. These categories emerged from the mapping exercise as being essential for the delivery of circular cities: resource optimisation and the regeneration of natural capital in cities (and thus are included in Figure 2)<sup>1</sup>.

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<sup>1</sup> An overall reduction in urban resource consumption by addressing system redundancies and inefficiencies through the use of improved technology or management strategies is required to reduce “waste”. Resource optimisation is a key goal for circular cities and is integral to all 5 strategies discussed at the workshop. Thus, it creates a common theme running throughout discussions. The regeneration of natural capital through ecosystem services - support (nutrient cycling and soil production), production (e.g. energy and food) or regulating services (e.g. carbon sequestration, climate regulation, hydrological regulation, air purification, etc) – is also integral for the long-term sustenance and renewal of the city. It enables cities to become producers (as well as consumers) of resources. It also addresses the degradation of natural capital (e.g. air and water pollution, contaminated land) and environmental hazards (e.g. flooding) which threatens the longevity of cities.



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Figure 2 - Circular Strategies

## 2.2 Data analysis

Data was collected from transcripts, video and sound recordings of the mapping exercises and plenary discussions. A qualitative approach was adopted to organise and analyse the data. The data was first aggregated and then coded. The team used an inductive approach to allow trends and themes to emerge organically without restricted guidance. The circular city strategies grouped around the seven themes outlined in Figure 2 (localisation, looping, substitution, adaptation, sharing, regeneration and optimisation). The challenges to circular transformations also grouped into seven themes outlined in Table 1. The knowledge gaps grouped around 4 key themes: definition, strategies, motivation and implementation.

Challenges	Description
1. Culture	Norms, ideas, customs and social behaviour of people
2. Economy	Production, distribution and consumption of goods and services
3. Physical environment	Natural and built environment
4. Political and leadership	Policy preferences, issues of government and leadership
5. Smart	Data, information, monitoring, knowledge
6. Institutional	Organisational structures, cultures and practices
7. Regulatory	Regulations, regulatory instruments and policies

Table 1. Challenges to transformation

### **2.3 Limitations**

Due to the expertise and interests of the workshop participants the focus of discussion was on the European conceptualisation of a circular city. This will skew our understanding of a circular city, potential challenges to transformation and knowledge gaps. Of course context will significantly impact on the nature of a circular city and strategies adopted. The aim of the Hub is to extend its scope in future projects and workshops particularly to understand the nature of circular city strategies in the developing world context.

## **2. Strategies**

The principal goal of adopting a circular approach within a city-region is to reduce resource consumption and waste production. It is also to ensure the long-term sustainability of the city-region's natural ecosystem and urban infrastructure. The resources affected by this approach include land, energy and water as well as materials (goods, infrastructure and materials). This can be achieved by adopting one or a combination of circular strategies. Seven strategies emerged from the workshop (Figure 2) and are described below. For each strategy, illustrative examples are given from the cities represented at the workshop.

### **2.1 The Local City**

The “local city” is one in which resource flows are localised. Renewable energy and organic food is produced locally (e.g. Bristol Energy Coop and Grow Bristol; Sutton Community Farm, London). Equally “waste” is assimilated locally, enabled by the provision of green infrastructure ( All Green Grid, London). A local currency helps to facilitate this by encouraging residents to buy locally produced resources (e.g. the Brixton Pound) and consume local services. Organisations which can build capacity (expertise, financial capital, etc) within communities to produce resources locally are essential (e.g. Repower London). Data platforms for monitoring resource flows in and out of the city-region help to establish opportunities for greater localisation ( e.g. Circle Scan Amsterdam).

### **2.2 The Looping City**

The “looping city” is one in which resources from one activity are recycled, re-used, recovered and used in another activity. Buildings and infrastructure are recyclable (e.g. Arup Circular Home, Sustainer Homes, Amsterdam) or can be refurbished; goods are up-cycled (e.g. Repair Cafes, Paris) and land is re-used. Energy is recovered from material waste and as a by-product from other processes (e.g. Moulinot Compost and Biogas, Paris). Integrated infrastructure might be used to facilitate the recycling of resources across urban sub-systems (e.g. Ecocycles, Stockholm). Equally more informal, people-based approaches to recycling, re-use and recovery could emerge (Solidarity Bank, Paris). Labelling systems (e.g. Rcube, Paris) which enable citizens to determine the quality of second-hand goods or resources will also assist in encouraging re-use and recycling.

### **2.3 The Substitution City**

The “substitution city” is one in which, activities and infrastructure are substituted for resource efficient, circular alternatives. Thus non-renewable resources are substituted with renewable resources in the supply chain (e.g. Moulinot Biogas, Paris; Bristol Energy Cooperative; Ecocycles Stockholm). The decentralised production of renewable energy may be enabled through the introduction of smart grids. Resource-based activities (e.g. driving a private vehicle) are replaced by service-based activities, for example driving a carpool vehicle (e.g. Car2go, Amsterdam). Physical activities are substituted with virtual activities (e.g. shopping, working, etc) and non-durable infrastructure is replaced with durable infrastructure ( e.g. Sustainer Homes).

### **2.4 The Adaptable City**

The “adaptable city” is one in which the urban fabric (infrastructure, buildings and spaces) can adapt to changing local conditions over time, thus avoiding technological lock-in and “wasting” resources. Infrastructure can be adapted for new activities and multiple uses (e.g. Hoffice, Stockholm). Buildings can be reconfigured for new household types (e.g. Sustainer Homes, Amsterdam). Building materials can be recycled and re-used (e.g. ARUP circular homes). The city will be able to adapt to physical changes, such as climate change, through the adoption of green and blue infrastructure (e.g. the All Green Grid in London) which will help to regulate CO<sub>2</sub> emissions, flooding and the heat island effect. Space within the city will also enable a shift towards localised patterns of resource production within the city-region (e.g. Bristol Energy Coop, Sutton Community Farm). Infrastructure and urban morphology will allow for adaptation. However, this will need to be supported by a socially resilient community which has the networks, resources and expertise to adapt to change.

### **2.5 The Sharing City**

The “sharing city” is one in which resources are swapped, exchanged, leased or jointly owned. Libraries for goods will enable residents to borrow rather than buy consumable items that they use for limited periods (e.g. Peerbygo, Amsterdam). Pooling of vehicles similarly enables businesses and residents to share vehicles in the city (e.g. Car2go, Amsterdam), freeing-up valuable space for other uses and eco-services. Collaborative and collective forms of housing (e.g. Stockholm cohousing) enable residents to share space, goods, bills and their lives with others living in the community. This has significant financial, social and environmental benefits. Websites and exchange platforms enable businesses to purchase collectively and share resources (e.g. Sharing



Peterborough). The sharing strategy will be co-ordinated and supported by “sharing ambassadors” (as in Amsterdam) from business, civil society and government.

## **2.6 The Regenerative city**

The “regenerative city” is one in which resources are produced, pollution is reduced, contaminated sites are remediated, climate and hydrological processes are regulated, biodiversity is protected and carbon is sequestered. The natural capital of the city and its surrounding region is regenerated and thus the support systems for the city are renewed. Land is protected in the city for the production of local resources, for example food and energy (e.g. Bristol Energy Coop, Sutton Community Farm, Grow Bristol). The production and distribution of decentralised energy is enabled through a smart grid. Citizen-led projects are supported by municipalities or other umbrella organisations which provide information, financial support, or enabling networks (Repower London). Green and blue infrastructure (rain gardens, green roofs and walls, reed-beds, retention ponds, community forests, etc) are used to regulate pollution, flooding, climate, CO<sub>2</sub> and protect biodiversity (e.g. Green Grid London) and thus are integrated into the urban fabric. The urban hinterland (city-region) is extremely important too in offering space for these productive, regulative and supportive eco-services.

## **2.7 The Optimising city**


































The “optimising city” is one in which resources are used as efficiently as possible. Overall consumption of resources is reduced (for example using smart grid technologies) and resource redundancies within cities (e.g. vacant land, empty buildings, under-utilised goods and vehicles) are addressed (e.g. Car2go, Peerbygo, Sustainer Homes, Sharing Peterborough). Potential for resource optimisation may be determined using tools such as Circle Scan. This strategic management of resources underpins the delivery of a circular city and cuts across all 6 strategies outlined (localisation, looping, substitution, etc).

In most instances these strategies will combine to deliver circular cities. The combinations of strategies adopted will vary with local circumstance. There are also overlaps between strategies which may be synergistic; or conflicting or just replicating. These relationships require further analysis.

## 2.8 Circular city plans from the workshop

All the cities represented at the workshop produced plans for achieving circularity, with the exception of Stockholm (links to the city plans can be found in Appendix C). Each was distinctly different and clearly reflected the context in which it was being implemented. Each adopted a different combination of the 7 strategies outlined above (Table 2).

Table 2 Current circular city plans

	Localise	Loop	Substitute	Adapt	Share	Regenerate	Optimise
Amsterdam							
Bristol							
London							
Peterborough							
Paris							
Stockholm							

**Amsterdam** aims to be a pioneer in Circular Economy. The city offers political support for the circular economy through funded experiments. It has adopted a range of strategies **looping, substitution, sharing, adaptation, localisation and optimisation**. It has funded localised circular experiments which test all these strategies. It is also developing a method for monitoring resource flows across the city-region (city scan). The city is using its enabling powers and financial resources to facilitate this transition process, supported by National Government.

**Bristol** has adopted a resilience strategy. This strategy is focussed on creating agile and connected communities which can adapt to change. However, it also prioritises the city-region operating within its environmental limits through adopting new behaviours and technologies. It promotes local production of resources (food and renewable energy) and recycling of materials. It also encourages the recycling of waste (e.g. organic waste composting schemes) and waste to energy. Thus, the city is adopting **adaptive, localisation, looping, regenerative and substitution strategies**. The city largely relies on its enabling (e.g. protecting infrastructure and land for local food supply) and procurement capacity (e.g. buying locally produced energy and food) to deliver this agenda.

The Greater **London** Authority (GLA) also has a vision for the circular economy. The vision focuses on the **looping, substitution and sharing strategies**. The GLA is keen to support new business start-ups, generate jobs and develop skills within the workforce which underpin the circular and sharing economies. The GLA is using its enabling (building networks, enabling dialogue and funding some experiments) and procurement powers to achieve this aim. Separate to this the GLA has an Infrastructure Strategy 2050 which supports infrastructure to promote resource **looping** and the production of localised renewable energy (**substitution and localisation**). It also has a Green Infrastructure Strategy, which coordinates the development of the London Green Grid. This will promote the **regeneration** of natural capital within Greater London.

**Peterborough** City Council set itself the goal of becoming a circular city. It has developed a circular strategy through a highly inclusive process (engaging with public, private sector institutions and civil society), focussed on **looping and sharing strategies**. These have led to the more efficient resource use (**optimisation**) and more **localised** resource flows. The council has taken an enabling role (due to its very limited financial resources) building the networks

and providing the communication platforms needed to facilitate discussions between local actors which will lead to the implementation of the circular agenda.

**Paris** has recently produced a white paper on the circular economy through a highly collaborative process. This outlines a comprehensive approach to a circularity covering **looping, substitution, sharing, localisation and optimisation strategies**. The drivers are social and environmental, but the emphasis is on social solidarity. It addresses social needs, providing accessible, essential resources and infrastructure to all. It also engages the wider community in circular projects, encouraging grass-root innovation and the development of social and human capital. The Paris region is using its regulatory and enabling powers to facilitate this transition, supported by National Government.








































**Stockholm** aims to become fossil fuel free by 2050. It does not have a circular plan as such, yet arguably it is the most advanced in adopting a circular approach. The city is focussed on reducing resource consumption and waste production at least in part through the use of eco-cycles. This strategic system adopts **looping, localisation and substitution strategies**. The city has provided very long-term support for environmental goals, opting to address this through the provision of local renewable energy, waste-powered district heating systems, energy efficient buildings, comprehensive and integrated green transport options, compact morphology, etc (**localisation, optimisation substitution**). It has also begun to adopt green and blue infrastructure for **regenerative** purposes. The introduction of smart grid in Stockholm will also enable the **optimisation** of energy use and facilitate the connection of renewable energy to the grid. Grass-roots **sharing** experiments – cohousing, Hoffice – have also sprung up, which also offer flexibility to **adapt** to changing lifestyles in the city. Stockholm City has used its regulatory, provisioning and enabling powers to deliver this transformation.

## 2.9 Circular experiments

A total of 21 circular experiments were identified across the six cities attending the workshop. All addressed at least one of the circular strategies outlined above, most addressed several (Table 3). They provide illustrative examples<sup>2</sup> of how the circular city strategies might be delivered.

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<sup>2</sup> A list of examples and their web links are provided in Appendix D. A brief description of each experiment is provided in Appendix E.

	Description	Location							
<b>Car2go</b>	Car sharing	Amsterdam							
<b>Circle Scan</b>	Monitoring resource flows	Amsterdam							
<b>Peerbygo project</b>	Peer sharing platform	Amsterdam							
<b>Sharing Ambassadors</b>	Network of key actors visioning and delivering sharing strategy	Amsterdam							
<b>Sustainer homes/Finch homes,</b>	Adaptable / autonomous houses	Amsterdam							
<b>Bristol energy Co-op</b>	Community production renewable energy	Bristol							
<b>Grow Bristol</b>	Urban farming enterprise	Bristol							
<b>Sutton Community Farm</b>	Urban farming coop	London							
<b>Brixton Pound</b>	Local currency	London							
<b>Repowering London</b>	Facilitators community-owned renewable energy	London							
<b>All green grid</b>	Strategic green infrastructure network across Greater London	London							







































	Description	Location							
<b>Sharing Peterborough</b>	Virtual sharing and exchange platform	Peterborough							
<b>Moulinot Compost and Biogas</b>	Recycle food waste	Paris							
<b>Rcube</b>	Second-hand product labelling system	Paris							
<b>Repair cafes</b>	Repair workshops	Paris							
<b>Solidarity Bank</b>	Recycling scheme	Paris							
<b>Stockholm cohousing</b>	Collaborative housing	Stockholm							
<b>Ecocycles</b>	City-wide closed-loop infrastructure	Stockholm							
<b>HOffice</b>	Home sharing for offices	Stockholm							
<b>Smart Grid</b>	-	Stockholm							
<b>Circular Homes</b>	Construction materials leased, recyclable and re-useable.	ARUP Concept							

Table 3 Circular Experiments

### 3. Challenges

Challenges to circular transformations need to be better understood. Each focus group was asked to identify the key challenges to implementing the circular strategy they had been assigned. This data was collected and collated for the whole group (i.e. covering all circular strategies). A total of 43 separate challenges were identified across the seven themes (cultural, economic, institutional, political, etc). The challenges appeared to vary depending on the strategies, although some were common to all see Figure 3. Due to limited time (and arbitrariness) weightings of relative importance were not assigned for each challenge.

#### 3.1 Cultural challenges

Circular culture (values, attitudes, identities and behaviours) will underpin the successful functioning of a circular city. Several cultural values and principles are fundamental for the adoption of circular practices. Culture's which value environmental protection, inter-generational equity, co-operation and cultural localism are more likely to adopt circular practices. These values underpin the fundamental behavioural building blocks for a post-material, circular society. Current cultural norms present a real challenge to the delivery of circular practices. Materialism and consumerism create cultural barriers to decoupling, **sharing, localisation and looping resources**. Competitive individualism and preference for private ownership challenges **sharing** behaviours and collaborative lifestyles. As society becomes more individualised, social capital appears to be eroded, thus limiting the **adaptive** capacity of communities. The changing demographics within cities will influence the diversity of cultural values and attitudes towards community production of food and renewable energy (**localisation, regeneration and substitution**) up-cycling and re-use (resource **looping**) and **sharing** resources. It is also likely to affect social (strength of social bonds and networks) and human capital (skills and expertise) which in turn influences the **adaptive** capacity of communities.



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Figure 3 - Challenges to Implementation



- LOCALISE
- LOOP
- SUBSTITUTE
- SHARE
- ADAPT
- REGENERATE
- OPTIMISE





### 3.2 Economic challenges

In a circular city the primary focus is on the decoupling of economic growth from resource use. For some workshop participants it also means a move towards slow growth or no growth. The macro-economy was seen as one of the greatest challenges to delivering circular cities. First, the economy is reliant on resource-based growth, yet **all circular strategies** seek to decouple economic growth from resource consumption. This suggests significant macro-economic restructuring will be required to deliver circular cities. In short, the new economy will need to move towards service-based, circular and sharing models as well as become more reliant on recycled and renewable resources. Within this framework new business models will be needed. However, testing new business models is risky for investors, which makes them less attractive to finance. These transaction costs could limit innovation.

Second, globalisation was seen as a challenge to the **localisation of material resource flows**. Few resource flows are contained within city- regions, which limits capacity for localised looping. Globalised flows increases vulnerability to global risks (e.g. global energy crises or fuel price rises). Greater local autonomy in the production and processing of resources (i.e. localised resource flows) would enable localised looping and reduce vulnerability to global trends. But it would require macro-economic restructuring and cultural shifts (moving demand towards local products). It would also require that strong links between the city and its hinterland were re-established. This would enable localised resource flows, local production of resources and provision of eco-system services (**localisation, substitution and regenerative**).

Third, most economies in Europe are still largely based on fossil fuels (although a process of decarbonisation has begun). Technological and institutional lock-in, combined with fossil fuel subsidies, creates a major challenge for shifting the energy mix towards renewables (**substitution and regenerative capacity**). Fourth, increasing value of real estate in European cities will also create a challenge to delivering localised resource flows, resource production and provision of ecosystem services (**localisation, substitution and regenerative capacity**) due to competition for space in cities. Land and buildings may also be under-utilised (**optimisation**) as their investment value increases. However, high land values could also encourage **sharing, looping and adaptive** activities, as the remaining space will need to be used more effectively.

### 3.3 Physical challenges

In a circular city, urban **infrastructure** and morphology are critical for enabling circular resource flows. Urban infrastructure is adaptable, flexible or recyclable. Urban systems are integrated to allow waste from one system to be used by another. Spaces and infrastructure are shared and cities supplied with renewable energy preferably from a local source. Infrastructure and land-use are planned to enable localised resource production, flows and to ensure local resources are fully utilised. Space will be needed for the production of resources and regulation of “waste”. Green and blue infrastructure will be needed to regulate and support the urban ecosystem as well as produce new resources (especially food and energy).

The natural environment (climate, vegetation, local resources, relief, etc) and built environment (buildings, energy, water, waste, transport systems) greatly influence the circular strategy to be adopted by a city. The inflexibility of existing infrastructure (due to cost of adaptation and socio-technical lock-in) reduces the **adaptive** capacity of a city and the potential for **substitution, looping, localisation, sharing, regeneration and optimisation**. For example, it is difficult and costly to adapt highly centralised grid energy systems to decentralised energy systems using renewable energy or waste.

Lack of space and vegetation also limits **regenerative** capacity and ecosystem services. Urban infrastructure systems (water, energy, transport, waste, etc) also tend to be linear and disconnected. This prevents the recycling, reuse or recovery of waste from one system as a resource for another (**looping**). However, the adoption of integrated circular infrastructure may also create a challenge to future **adaptation** within cities, as it can also create a socio-technical lock-in.

### 3.4 Political and leadership challenges

Political support for a circular agenda is essential for a successful transformation. Prioritising pro-environmental policy goals (e.g. resource stewardship, double-decoupling, low carbon) is helpful for delivery. A lack of strong political leadership on environmental agendas is a challenge to implementing all the circular strategies. However, circular solutions could be used to solve a variety of local problems for example housing shortages, fuel poverty, and unemployment, caring for an ageing population, air pollution, flooding. By focussing on these social, economic and environmental priorities, broader political support for delivery could be built. Thus, circularity should be seen by politicians as a strategy for achieving other policy goals (not as an end in itself).

A long-term vision will be needed for the transformation to be successful given the scale of the cultural and economic shift required to deliver a circular city. Yet political cycles are short and policy changes often. This lack of long-term political vision will challenge transformation. Constant changes to political agendas and instruments have undermined investment in new business models, technological innovation and infrastructural transformation, and will continue to do so. This was most clearly demonstrated in the UK by the changing policy and subsidies for decentralised renewable energy. Ultimately this will impede the delivery of **all circular** strategies. A lack of direction on competing priorities for land in cities also presents a major challenge for delivering **regenerative, substitution** and **localisation** strategies. If a robust case for circular solutions can be made, then a longer term commitment to delivery should be possible. This would reduce uncertainty amongst innovators and investors, and enable land to be protected for these purposes.

Greater local autonomy and stronger linkages between the city and its hinterland through the creation of city-regions, will assist in delivering the **localised, regenerative** and **looping** strategies. However, competition between cities (and administrative areas) is likely to challenge this approach. Encouraging grass-roots innovation, by protecting and supporting circular experiments, could assist the transformation process. Municipalities should provide leadership using their regulatory, provisioning, enabling and purchasing powers as well as local resources (land, finance, and expertise, networks) to achieve this. Yet municipal competencies and resources are being eroded which has a potentially negative impact on all circular strategies. Engagement of civil society in decision-making processes and implementing circular strategies is critical to success. The co-production of solutions, involving a range of urban actors, working within clear, performance-based parameters should ensure resource consumption reduces but that strategies remain context appropriate. Yet public engagement in decision-making and implementation is still limited. Again this threatens the successful delivery of the circular agenda.

### **3.5 Institutional challenges**

The inflexibility of institutions; their lack of engagement with civil society, and the involvement of global institutions in local service delivery were seen as major challenges to **all circular** strategies. In combination these factors also resulted in a lack of public trust in institutions. Inflexible institutions created barriers to **substitution** and **adaptation**. Greater public engagement in decision-making and delivery will help to change values, motivations and behaviours and generate support for the circular activities. Greater local accountability of global institutions involved in local service delivery will also help to deliver a circular agenda (presuming local political support for such an approach) and build public trust.

Alternatively greater engagement of local institutions in the delivery of resources, infrastructure and services will increase local autonomy, thus enabling the delivery of **all circular** strategies. However, erosion of municipal competencies (particularly provision and regulation) and resources (publicly owned land and local public finance) is currently threatening the delivery of **all circular strategies**. The privatisation of services, space and infrastructure has influenced a city's ability to **loop, substitute, localise, adapt, optimise and regenerate**. It also limits the potential to **share** space.

Localisation of resource flow is limited (particularly in the UK) by the lack of a city-regional view and lack of local autonomy. **Localisation, looping, substitution and regenerative strategies** will operate more effectively at a city-regional scale. However, existing administrative boundaries create problems in resource planning at a city-regional scale (**localisation**).

Moving towards circular strategies will also require the widespread adoption of new institutions and ownership models for circular, sharing and service-based economies. A current lack of suitable institutions and ownership models is slowing the development of these new economies. Finally, cultural, structural and practice-based inertia within existing institutions creates a very significant barrier to circular transformation across all strategies. This is exemplified by siloed-thinking in institutions, which challenges the delivery of **localised, integrated, looping** systems.

### 3.6 Regulatory challenges

A supportive, cross-sectoral, multi-level regulatory framework will be essential for the delivery of the circular city. Co-ordinated performance-based targets to prevent waste (materials, energy, water and land) across all sectors, legally enforced or financially penalised, will be required. This will assist in goal alignment amongst urban actors and encourage them to cooperate in delivering circular strategies (i.e. sharing, looping, substitution, etc). Legal frameworks to support the new models emerging from the circular, sharing and service-based economy will be vital.

Currently the supportive, multi-level regulatory framework needed to underpin a shift towards circular strategies is under-developed. There is also a lack of co-ordination of regulations across sectors (energy, material waste, water, land) and scales (local, regional, national, international). This creates regulatory conflicts and is particularly a problem for delivering **looping and substitution** strategies (although it affects all). A regulative framework which promotes cross-sectoral, multi-scalar solutions needs to be developed. However, the inter-dependencies between resource systems and sectors could also create

major difficulties in regulating them (**looping and substitution**). A more holistic view and deeper understanding of these interdependencies will be needed if regulation is to be effective and not create negative feedback.

Planning is one regulatory instrument with a key role to play in implementation at a city-level. Planning provides a platform and process which enables collaborative relationships to become established between urban actors, and thus generate opportunities for forming partnerships which enable **looping** and **sharing**. A more integrated approach to resource and urban systems planning can enable the integration of resource flows, **optimisation** of resource use, resource **looping** and **substitution**. Of course strategic planning's main function is to guide land use, and as such it has a major role to play in the **localisation** of activities and resultant resource flows. Planning can also mediate in land markets, and can prioritise the protection and/or provision of green infrastructure in cities. Thus it also has a key role in **regenerating** natural capital. Planning is currently under-utilised in the delivery of **all circular** strategies. Moving towards a form of planning which encourages the integrated management of resources within city-regions, with the collaborative involvement of all urban actors in the creation and implementation of a circular strategy, will provide another major challenge.

New regulatory challenges - liability, ownership and privacy - have also emerged particularly around the **sharing** and service-based economies. The introduction of smart grid to optimise resource flows and facilitate the use of decentralised renewable energy (**optimisation and substitution**) has also created regulatory challenges over the ownership of data it produces; privacy of customers and security of customer data and energy systems.

### **3.5 Information challenges**

In a circular city smart data will be used to determine potential solutions, change behaviour, guide and monitor policy decisions. Smart data will be used to monitor resource flows in cities, identifying inefficiencies and opportunities for **optimisation, localisation and looping**. Smart grid will enable the connection of more intermittent and smaller scale renewable energy sources to the grid (**substitution**). Smart data will be used to change behaviour using resource metering (**optimisation**), or apps which enable sharing or re-using materials, goods and space (**looping and sharing**). Data which monitors natural capital in cities and the effectiveness of ecosystem services is essential for ecological **regeneration**. Data will be co-produced in order that the socio-technical systems can co-evolve with the needs of citizens. Digital platforms for sharing information will be essential for identifying opportunities and

building the social capital needed for exchange to take place. Virtual environments may offer virtual services and locations thus substituting physical resources and space. Thus, data and virtual environments are fundamental for the delivery of circular strategies.

Currently the key data challenge centres around access. Data is collected in an ad hoc fashion, and does not provide a comprehensive picture of resource flows or eco-system services in cities. There are issues surrounding ownership of the data, the security of data and privacy for individuals to whom the data belongs. There is a lack of data sharing platforms to enable information to be exchanged and circular practices to develop. There is also a lack of knowledge about what type of data is needed to design, implement and monitor circular strategies

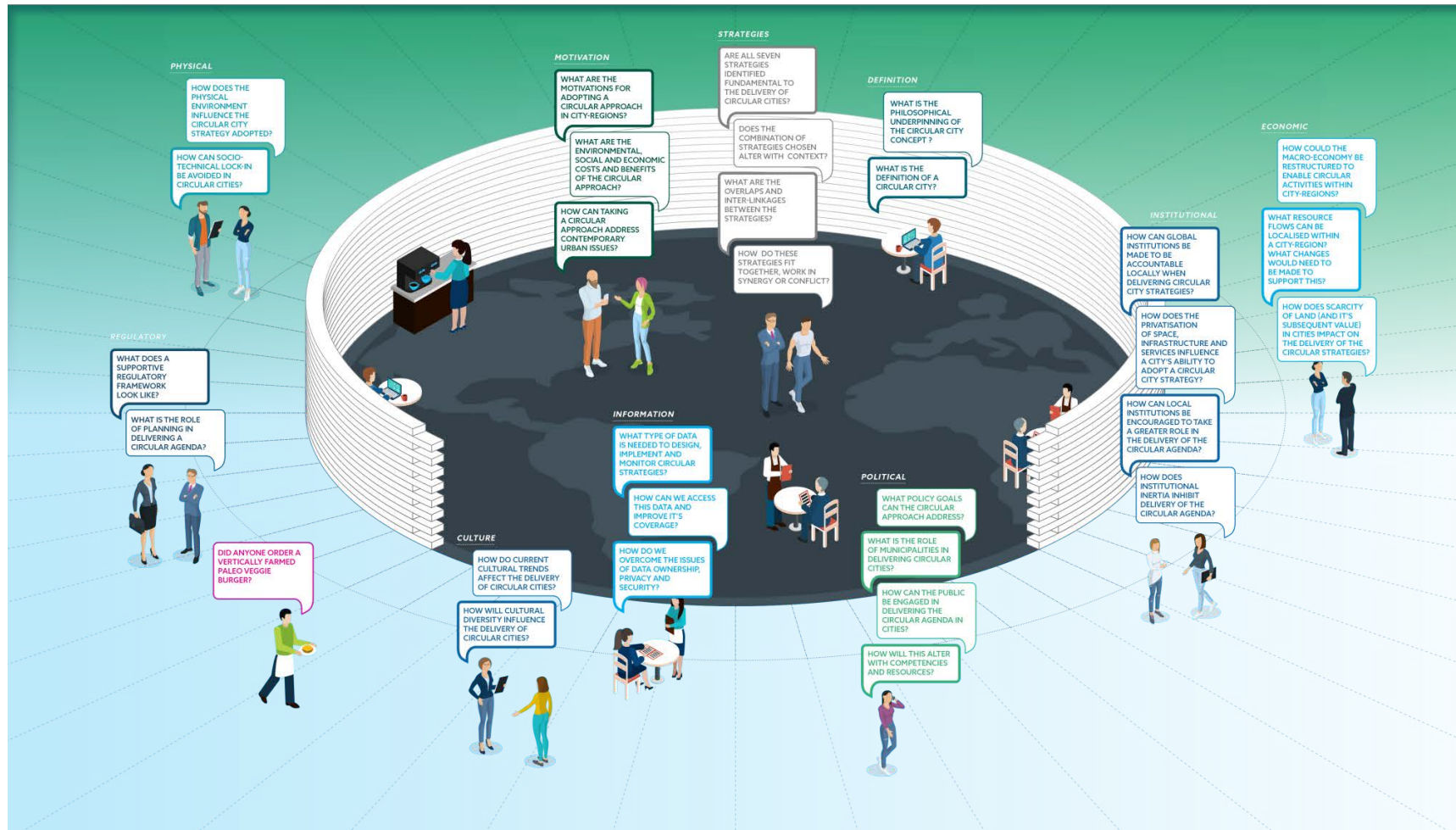
Thus there are a variety of challenges to delivering circular cities. These challenges vary depending on the preferred strategy and the context into which it is implemented. This is an area which requires extensive further research.

#### **4. Knowledge gaps**

This section presents the knowledge gaps which create a fundamental barrier to our understanding and implementation of circular cities, as identified by workshop participants. Four themes emerged around definition, strategies, motivations and challenges to implementation (Figure 4).

##### **4.1 Definition**

First, there was some discussion around the definition of circular cities. It was agreed that developing a clear definition would be useful. It would be important to build on those definitions already in circulation (i.e. circular economy, zero waste cities, regenerative cities, sustainable cities, resilient cities) and ensure a clear distinction between them. Decoupling resource consumption from production and economic growth was the prime goal for circular cities. However, the circular city should be more than a model for urban consumption and production. It should also consider questions of intergenerational equity, community engagement and participation, social and environmental justice. Crucial to the definition is whether economic growth (slow or otherwise) fits with a circular agenda. Inter-generational equity, resulting in the need to regenerate the natural and built environment in cities, is also very important and needs to be incorporated into a definition. Thus, a clear indication of the philosophical underpinning of the concept is needed, in order that appropriate goals, strategies and policies for delivery can be developed. This requires further research.



## **4.2 Strategies**

Second, five strategies for delivering circular cities were presented at the workshop (looping, adaptation, localisation, sharing and substitution). This drew from and modified the circular economy definition developed by the Ellen MacArthur Foundation. Crucially it added localisation to the strategies which could be used to encourage circular resource flows in city-regions. However, two additional important strategies emerged from the workshop - optimisation and regeneration. It was suggested that optimisation of resource use would need to underpin all circular strategies to avoid the rebound effect long-term. Regenerating natural capital in cities was also identified as an important for delivering the circular agenda, as it would ensure the long-term health of the city and its population. There were questions as to whether all seven strategies were fundamental to the delivery of circular cities or whether a combination of strategies could be chosen to suit the context in which they were applied. This requires further research. There also appeared to overlaps and inter-linkages between the seven strategies. More research is needed into how these strategies fit together, work in synergy or conflict with each other.

## **4.3 Motivation**

Third, the need to determine the motivation for adopting a circular approach in city-regions was raised. To understand this we must investigate the environmental, social and economic costs and benefits of the circular approach. We must also identify the manner in which taking a circular approach might help to address contemporary urban problems (for example lack of affordable housing, poverty and unemployment, health problems relating to pollution, empowerment of local communities, caring for the ageing population, addressing climate change, etc). Exploration of the motivations for adopting circular approaches requires further research.

## **4.4 Challenges to implementation**

Fourth, various challenges to implementation exist which make the transformation towards a circular city difficult (as identified in Section 3). The key research questions arising from this cut across cultural, economic, physical, political, institutional, regulatory and informational challenges (Figure 4). In addition the relative importance of these challenges (i.e. impact on delivery) and order in which they need to be solved to enable effective implementation,



requires further thought. There is a great deal more research which is needed to determine the answers to some of these critical questions. The Hub intends provide a vehicle through which this can happen.

## 5. Concluding remarks

This report provides us with a clearer understanding of what a circular city is from a European perspective. It illustrates a series of seven circular city strategies. It demonstrates how these circular strategies might be combined by outlining the approaches adopted by six European cities. It also introduces the circular experiments emerging in each of these cities.

The report highlights the potential challenges faced by cities undergoing circular transformations. It subdivides these challenges into seven themes (cultural, economic, institutional, etc). It identifies which of the seven circular strategies the challenges are most likely to affect. Some challenges will be problematic for all seven strategies (e.g. the lack of a supportive regulatory framework). From this initial analysis it seems that institutional and economic challenges are likely to create the greatest barriers to circular transformation, followed by regulatory and political challenges.

Finally, the report raises many questions in terms of definition; strategy combinations; motivation for adopting circular approaches and challenges to implementation. This begins to sketch out a research agenda for those working on Circular Cities. It is clear a significant amount of research is needed before we can expect to deliver circular cities successfully or even make a water-tight argument for this approach.

If you would like to be involved in continuing research and discussions do join our LinkedIn group, visit our website or contact the Director of the Circular Cities Hub.

Website <http://circularcitieshub.com/>

LinkedIn Circular Cities Research Hub

Director of the Circular Cities Hub Joanna.williams@ucl.ac.uk

**Appendices**

## A. List of participants

<b>Participant</b>	<b>Affiliation</b>		
Aiduan Borrion	UCL	Geoff Stevens	Future Cities Catapult
Amy Brown	Scottish Cities	Hitomi Roppongi Fujiii	UCL
Andy Ridley	Circle Economy	Ine Steenmans	UCL
Arjan van Timmeren	TU Delft	Ingmarie Ahlberg	Stockholm City Council
Ashima Sukhdev	Ellen MacArthur Foundation	James Hobson	Buro Happold
Ben Croxford	UCL	Jeremy Skinner	GLA
Carine Saloff-Coste	City of Paris	Jess Brodrick	LWARB
Catalina Turcu	UCL	Jessica Ferm	UCL
Chris Rogers	University of Birmingham	Jessica Lewis	London Councils
Colin Turnbull	SP Parsons Brinckerhoff	Jim Coleman	Buro Happold
Dave Smith	Aecom	Jo Williams	UCL
David Tozer	WRAP	Joerg Knieling	Hafencity University Hamburg
Davide Poggio	University of Surrey	Jim Ju Eun	UCL
Ellen van Bueren	TU Delft	Julia Vol	Ellen MacArthur Foundation
Emma McKenna	Peterborough City Council	Kato Allaert	University of Antwerp
Enora Robin	UCL	Katrien Steenmans	UCL
Fangzhu Zhang	UCL	Kersty Hobson	Cardiff University
Filippo Boselli	World Future Council	Keven Tinkham	Tata Steel
Gary Grant	Green Infrastructure Consultancy	Louise Guibrunet	UCL
		Maja Johannessen	Ellen MacArthur Foundation
		Marcus Manning	Future Cities Catapult

Mike Raco	UCL	Sam Bradley	GO-Science
Monica Lof	UCL	Sarah Toy	Bristol City
Na'amah Hagiladi	Arup	Sharon Prendeville	University of Loughborough
Nick Voulvoulis	Imperial College	Stefania Fiorentino	UCL
Niraj Saraf	Innovate UK	Stephen Passmore	The Ecological Sequestrian Trust
Oksana Mont	Lund University	Stuart Smith	Arup
Patricia Canelas	UCL	Tim Pryce	Carbon Trust
Pierre Laconte	FFUE	Tommaso Gabrieli	UCL
Robin Yeoman	Google	Ulf Ranhagen	KTH Stockholm
Rosalind Malcolm	University of Surrey	Yvonne Rydin	UCL

## B. Workshop structure

**9.00 – 9.30 Registration**

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**9.30 – 10.15 Circular Cities Hub introduction**

- *Jo Williams, Circular Cities Hub Director, UCL*
- *Ashima Sukhdev, Ellen MacArthur Foundation*
- *Filippo Boselli, World Future Council*
- *Sam Bradley, Government Office for Science*

**10.15 – 11.25 Session 1: City strategies**

- *Jeremy Skinner, Greater London Authority*
- *Carine Saloff-Coste, City of Paris*
- *Ingmarie Ahlberg, City of Stockholm*
- *Ellen van Bueren, TU Delft*
- *Sarah Toy, Bristol City Council*
- *Emma McKenna, Peterborough City Council*

**11.25 – 11.35 Break**

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**11.35 – 12.20 Visioning workshop**

*Break out into five groups on each of the themes*

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**12.20 – 12.50 Plenary**

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**12.50 – 13.45 Lunch and networking**

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**13.45 – 13.50 Session 2: Identifying challenges**

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**13.50 – 14.30 Challenges workshop**

*Break out into five groups on each of the themes*

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**14.30 – 15.00 Plenary**

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**15.00 – 15.15 Break**

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**15.15 – 16.15 Session 3: Current research**

- *Ulf Ranhagen, KTH Stockholm / SWECO*
- *Oksana Mont, University of Lund*
- *Joerg Knieling, HafenCity University Hamburg*
- *Arjan van Timmeren, TU Delft*
- *Jo Williams, UCL*

**16.15 – 16.55 Knowledge gaps workshop**

*Break out into five groups on each of the themes*

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**16.55 – 17.25 Plenary**

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**17.25 – 17.30 Closing remarks and future plans**

## C. Circular city strategies

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### Strategies

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Paris <https://api-site.paris.fr/images/77050>

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Amsterdam <https://www.amsterdam.nl/bestuur-organisatie/organisatie/ruimte-economie/ruimte-duurzaamheid/making-amsterdam/circular-economy/report-circular/>

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Stockholm <https://sweden.se/nature/sustainable-living/>

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London [http://www.lwarb.gov.uk/wpcontent/uploads/2015/12/LWARB-circular-economy-report\\_web\\_09.12.15.pdf](http://www.lwarb.gov.uk/wpcontent/uploads/2015/12/LWARB-circular-economy-report_web_09.12.15.pdf);  
<https://www.london.gov.uk/what-we-do/business-and-economy/better-infrastructure/london-infrastructure-plan-2050>

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Bristol <https://www.bristol.gov.uk/policies-plans-strategies/bristol-resilience-strategy>

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Peterborough <http://www.peterboroughdna.com/circular-economy/>

#### D. Experiment Links

Stockholm Cohousing	<a href="http://www.kollektivhus.nu/english/index_eng.html">http://www.kollektivhus.nu/english/index_eng.html</a>
Bristol Energy Cooperative	<a href="http://www.bristolenergy.coop/">http://www.bristolenergy.coop/</a>
Sutton Community Farm	<a href="http://suttoncommunityfarm.org.uk/about-us-sutton-community-farm/">http://suttoncommunityfarm.org.uk/about-us-sutton-community-farm/</a>
Car2 go	<a href="https://www.car2go.com/NL/en/amsterdam/">https://www.car2go.com/NL/en/amsterdam/</a>
Brixton pound	<a href="https://brixtonpound.org/">https://brixtonpound.org/</a>
Amsterdam's Circle Scan	<a href="http://circle-economy.com/amsterdamcirclecitescan">http://circle-economy.com/amsterdamcirclecitescan</a>
Moulinot Compost and Biogas	<a href="https://www.zerowasteurope.eu/2014/02/moulinot-closing-the-loop-for-restaurant-food-waste-in-paris/">https://www.zerowasteurope.eu/2014/02/moulinot-closing-the-loop-for-restaurant-food-waste-in-paris/</a>
Peerby Go project	<a href="http://press.peerby.com/110784-sharing-platform-peerby-launches-peerby-go-renting-from-neighbors-including-delivery">http://press.peerby.com/110784-sharing-platform-peerby-launches-peerby-go-renting-from-neighbors-including-delivery</a>
Circular building (ARUP)	<a href="http://circularbuilding.arup.com/">http://circularbuilding.arup.com/</a>
Finch Buildings	<a href="http://www.finchbuildings.com/en/">http://www.finchbuildings.com/en/</a>
Sustainer Homes	<a href="http://www.iamsterdam.com/en/business/circular-economy/circular-initiatives-in-amsterdam/sustainer-homes">http://www.iamsterdam.com/en/business/circular-economy/circular-initiatives-in-amsterdam/sustainer-homes</a>
Ecocycles	<a href="http://reflow.stockholm.se/#/energy">http://reflow.stockholm.se/#/energy</a>
HOffice	<a href="https://citiesintransition.eu/cityreport/hoffice">https://citiesintransition.eu/cityreport/hoffice</a>
Zed Pods	<a href="http://www.zedfactory.com/zed-pod">http://www.zedfactory.com/zed-pod</a>

Sharing Peterborough	<a href="http://www.peterboroughdna.com/demonstrators/">http://www.peterboroughdna.com/demonstrators/</a>
Smart Grid Stockholm	<a href="http://www.s3c-project.eu/News/83/StockholmRoyalSeaport.html">http://www.s3c-project.eu/News/83/StockholmRoyalSeaport.html</a>
Reflow	<a href="http://reflow.stockholm.se/#">http://reflow.stockholm.se/#</a>
RCube	<a href="https://api-site.paris.fr/images/77050">https://api-site.paris.fr/images/77050</a>
Repowering London	<a href="http://www.repowering.org.uk">http://www.repowering.org.uk</a>
Solidarity Bank for household articles	<a href="https://api-site.paris.fr/images/77050">https://api-site.paris.fr/images/77050</a>
Sharing ambassadors	<a href="http://www.sharenl.nl/amsterdam-sharing-city/">http://www.sharenl.nl/amsterdam-sharing-city/</a>
Repair Cafés	<a href="https://api-site.paris.fr/images/77050">https://api-site.paris.fr/images/77050</a>
All London Green Grid	<a href="https://www.london.gov.uk/WHAT-WE-DO/environment/parks-green-spaces-and-biodiversity/all-london-green-grid">https://www.london.gov.uk/WHAT-WE-DO/environment/parks-green-spaces-and-biodiversity/all-london-green-grid</a>
Grow Bristol	<a href="http://growbristol.co.uk/">http://growbristol.co.uk/</a>



## E. Experiment Details

### Amsterdam

- Sharing ambassadors (Amsterdam) is a network of 35 ambassadors in key organisations from the private, public sectors and civil society in the city. The network has created a sharing vision and is now collaborating on concrete projects across the city. This has produced 40 start-ups to date (**sharing**).
- Peerby Go project in Amsterdam enables neighbours to rent household items from their neighbours. Peerby provides a sharing platform and manages supply and demand (**sharing**).
- Amsterdam's Circle Scan – the scan is a program designed to monitor resource flows within city regions. It encourages circular supply chains, re-use, recycling and recovery in the construction sector and for organic waste in Amsterdam (**looping and localisation**).
- Car2 go (Amsterdam) is a car-sharing scheme which reduces car ownership and the need for parking in the city (**substitution and sharing**).
- Flexible buildings (Finch Buildings) and Autonomous houses (Sustainer Homes) in Amsterdam. Finch Buildings are wooden

modular buildings that are highly adaptable. The blocks can be combined to form any kind of building, from student accommodation, care homes to holiday apartments and hotels (**adapt**). Sustainer Homes are built from old shipping containers and can be moved anywhere (**looping and adapt**).

### Bristol

- Grow Bristol is an urban farming enterprise, which grows food locally and employs local people. The enterprise uses renewable energy and aims to reduce the water footprint for market gardening (**regenerating natural capital, substitution and localisation**).
- Bristol Energy Cooperative is a community owned renewable energy cooperative which enables the citizens to co-produce local low carbon, renewable energy for the city (**regenerating natural capital, substitution and localisation**).

### London

- All London Green Grid is a strategic green infrastructure plan for the capital. It includes a vast range of solutions from rain gardens and green roofs in dense commercial areas to community forests, parks and allotments in inner and outer London. It

provides the opportunity to grow food locally, attenuate flooding, improve air quality, reduce CO<sub>2</sub> emissions as well as providing local leisure space (**localisation and regenerating natural capital**).

- Repowering London is a not-for profit organisation enabling community-owned renewable energy projects. Co-production raises awareness and encourages pro-environmental behaviour. It also localises the production renewable energy (**substitution and localisation**). Schemes are currently running in the London Boroughs of Lambeth, Haringey and Hackney.
- Sutton Community Farm (London) is a community-owned social enterprise. It grows fresh, healthy, sustainable food and provides a shared space for people to cultivate skills, get exercise and socialise. The farm sells a wide range of organic veg boxes via their online shop (**sharing, regenerating natural capital, substitution and localisation**).
- Brixton pound (London) is local currency used to support the local economy in Brixton. It has encouraged localised resource flows and the generation of community renewable energy (**substitution and localisation**).
- Circular building (ARUP) the materials used in construction are leased and are re-useable or recyclable. The buildings are easily

constructed, de-constructed or adapted for new uses (**looping , substitution and adapt**). Zed Pods offer affordable, fully autonomous homes which fit over parking spaces and can be moved to new locations (**looping and adapt**).

### Peterborough

- Sharing Peterborough provides an online platform through which businesses in Peterborough can exchange goods and services (**substitution, sharing, looping and localisation**).

### Paris

- Moulinot Compost and Biogas (Paris) is a scheme to recycle food waste, particularly from restaurants and cafes in Paris, to create compost and biogas (**looping and localisation**).
- RCube second-hand product labelling system in Paris provides information about the quality of second-hand equipment to encourage waste reduction, re-use and re-utilization (**looping**).
- Repair Cafés (Paris) are cooperative repair workshops set up to give objects a second life. Free and open to everyone, these workshops are run by volunteer DIY enthusiasts who share their

know-how and expertise with those bringing objects for repair **(looping, adapt)**.

- Solidarity Bank for household articles (Paris) provides low-priced household articles (dishes, furniture, electrical appliances, linen, etc.) to people living in precarious situations who are accessing permanent housing. This initiative is made possible through partnerships with large companies that donate their unsold or discontinued goods **(looping)**

### Stockholm

- Cohousing (Stockholm) is a form of housing which encourages a collaborative lifestyle **(looping and sharing)**. Households have individual living spaces and communal facilities (café, workshop, gardens, storage space, gym, guest rooms, etc) which they share. They are involved in the design, operation of the community and also finance the development collectively. In cohousing space and goods can be shared between residents and pro-environmental behaviours (recycling, re-use) adopted. Cohousing also offers a more supportive, **adaptive** and affordable living environment for the more vulnerable in society (elderly, children, single parents, etc).

- Ecocycles in Stockholm is a localised, integrated, closed-loop, infrastructural system in which organic waste and waste heat is recycled or recovered and used for cooking, powering public transport services and buildings, and to produce compost. The system also draws on local renewable energy sources **(looping, localisation and substitution)**.
- HOffice in Stockholm is a scheme where people open up their homes as work spaces within the community. The scheme encourages space sharing and creates flexible space in the city. It also helps to build social and knowledge capital **(localisation, sharing and adapt)**.
- Smart Grid Stockholm is being developed in the Royal Seaport. It enables smart buildings and electric vehicles to be connected to distributed renewable energy. It encourages citizens to monitor the energy they generate and consume. It also allows them to identify the most energy consuming activities and devices, which in turn informs their behaviour **(renewable supply chain)**.
- Reflow Stockholm has also been developed for the Royal Seaport. It is an educational tool which shows the integrated flows of energy, water and materials in the urban district **(looping)**. It is hoped that Reflow will also modify citizens consumption patterns and behaviour.

