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Indicators for circular economy (CE) transition in cities - Issues and mapping paper

(Version 4)

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Acronyms

AIT	Austrian Institute of Technology
CE	Circular Economy
CEENE	Cumulative Energy Extracted from the Natural Environment
CEPS	Centre for European Policy Studies
CIRCTER	Circular Economy and Territorial Consequences
CO_2	Carbon dioxide
DEU	Domestic extraction used
DG ENV	Directorate-General for Environment
DG REGIO	Directorate-General for Regional and Urban Policy
DMC	Domestic material consumption
e.g.	*exempli gratia* (“for example”)
EC	European Commission
EEA	European Environment Agency
EMAS	Eco-Management and Audit Scheme
EOL-RIR	End of Life Recycling Input Rate
EU	European Union
GHG	Greenhouse gases
GVA	Gross value added
i.e.	*id est* (“that is”)
I/O	input/output
ISO	International Organization for Standardization
kWh/m^2	Kilowatt-hours per square meter
LWARB	London Waste and Recycling Board
MFM(+)	(extended) Material flow monitoring
MSE	Material system analysis
NACE	Statistical classification of economic activities in the European Community
OECD	Organisation for Economic Co-operation and Development
PhD	Doctor of Philosophy
PREC	Programme Régional en Economie Circulaire
RD&D	Research, development and demonstration
RME	Raw material equivalents
RMS	Raw material consumption
SCREEN	Synergic Circular Economy across European Regions
SIC	Standard Industrial Classification
sq.m	Square metre
t/cap/year	tonnes per capita per year
TNO	Netherlands Organisation for Applied Scientific Research
VTT	Technical Research Centre of Finland
WEEE	Waste electrical & electronic equipment

1 Background

This Issues and mapping paper on indicators for circular economy (CE) transition in cities was developed under the framework of the Urban Agenda and the Partnership on Circular Economy. This fourth version of the paper presents the final results of the mapping exercise and consolidates all input on CE indicators and issues highlighted by stakeholders (cities, academics, and networks) in the period September 2018 – April 2019.

This section starts with a short introduction of the Urban Agenda and the Partnership on Circular Economy. Then it presents the rationale for the study and a draft definition of Circular Economy (CE) that will guide the mapping of relevant indicators.

1.1 The Urban Agenda

The Urban Agenda aims to contribute to Better Regulation, Better Knowledge and Better Funding for cities and citizens. The Urban Agenda for the EU was launched in May 2016 with the Pact of Amsterdam. It represents a new multi-level working method promoting cooperation between Member States, cities, the European Commission and other stakeholders in order to stimulate growth, liveability and innovation in the cities of Europe and to identify and successfully tackle social challenges.[1] The Partnership on Circular Economy is one of currently 12 Partnerships, established in January 2017 for a duration of 3 years. It is coordinated by the City of Oslo (Norway), and has a broad membership of cities, Member States and the EC (DG REGIO, DG ENV) as well as other stakeholders.[2]

The Partnership is currently preparing its Action Plan and has developed Scoping Papers and Action Sheets, which cover the direction of its work. The first part of the draft Action Plan has been approved in April 2018 and the second part during the Fall of 2018.

The Partnership is supported by a Technical Secretariat (Ecorys), which is funded by a framework contract issued by EC DG REGIO. This paper was prepared as a part of the Technical Secretariat services.

1.2 Rationale for the study – indicator needs and challenges

The EU Commission launched in January 2018 a monitoring framework for the Circular Economy. The indicators proposed by the Commission are intended to help Member States to develop a Circular Economy strategy, and to eventually report on the overall progress of the transition towards a Circular Economy in the EU.

Through the implementation of a Circular Economy approach, cities have experienced the need of indicators for monitoring and to report on their efforts and achievements. The Partnership on

[1] EC. 2018. "Urban Agenda for the EU - FUTURIUM - European Commission". 2018. Available at: https://ec.europa.eu/futurium/en/urban-agenda.
[2] EC. 2018. "Members - FUTURIUM - European Commission". Available at: https://ec.europa.eu/futurium/en/node/2231.

Circular Economy has identified the lack of such indicators as a bottleneck for cities in implementing a Circular Economy strategy.

Measuring the performance of cities in their shift towards a Circular Economy provides an opportunity for cities to self-assess their achievements, to identify barriers as well as opportunities and to adapt accordingly their development trajectory towards circularity. From these considerations emerges the need for a sound and realistic framework of indicators for a Circular Economy transition in cities.

More specifically, the following **needs** concerning Circular Economy indicators have been identified through interactions with stakeholders (especially via a workshop on the 12th of September, 2018 in Brussels) under the Partnership activities:

- Need for a shared view on Circular Economy indicators among authorities and policy-makers;
- Conceptual underpinning of an indicator framework, which addresses appropriateness and availability of data. The conceptual basis of a monitoring system determines the feasibility to deal with information in those areas where data for circular economy are not currently immediately available;
- The conceptual framework should explore the need for:
  - overarching indicators that run across different themes (*e.g.* CO_2 emissions);
  - thematic indicators; city-specific indicators (*i.e.* bottom-up indicators that can be in the form of a checklist).
  - Furthermore, the conceptual framework should explain the theory of change and define the levels of applicability of indicators – context and objectives (short-term and long-term);
- Indicators that are aligned to some extent to the EU monitoring framework for the Circular Economy, *i.e.*: a simple and effective monitoring framework; the need for a monitoring framework to strengthen and assess the progress towards Circular Economy, while minimising the administrative burden;
- Indicators on Circular Economy may be part of a self-assessment tool but also allow for a comparison across cities in Europe;
- Clarity about definitions – on Circular Economy at the city level cities, but also on more technical issues, *e.g.* municipal waste (including industry waste), packaging waste, jobs in the Circular Economy sector;
- There is a need to take stock of all initiatives that are relevant to the development of Circular Economy indicators, including Horizon 2020 projects;
- Indicators should make the best possible use of existing data (even though some cities have resources for data gathering, *e.g.* surveys amongst companies);
- The cost to introduce indicators should be considered – indicators should be as simple, as possible;
- Awareness-raising and the importance of mainstreaming (bringing a large group of companies and citizens into the understanding of Circular Economy) is an important aspect that may be captured by indicators;
- Inventory of cities with roadmaps and indicators would be useful and there could be follow-up meetings between them and/or a pilot project on exchange of information on setting up Circular Economy indicator systems;
- Practical guidance how to implement Circular Economy indicators at city level would facilitate the application of indicators.

In addition to the above needs, the mapping exercise has also identified the following **challenges**:

- It is difficult to capture the industrial symbiosis through indicators;
- How to monitor progress on the Circular Economy and macro-level when the baseline is so limited;
- There is a substantial time lag – when to expect effects and communicate them;
- Measuring circularity at a city level requires both a city wide Circular Economy metrics and a municipality narrative (*e.g.* case studies on micro-initiatives);
- If data sources like surveys are identified for indicators, it should be considered that operationalising the concept of Circular Economy in surveys is very difficult;
- The value of comparisons between cities may be questionable due to their specificities and different available statistics. Since objectives and indicators should be linked, different objectives would make difficult comparisons between cities;
- Cities already have carbon emission targets, but it is difficult to assess how much the Circular Economy can contribute to those targets;
- It is challenging to have indicators that can be measured on an annual/regular basis at a city-level;
- Conceptually, instead of developing CE indicators per se, some assert (e.g. see the Resourceful Belfast initiative[3]) that it could be better to develop Resource Efficiency indicators against which CE solutions can be measured.

1.3 Defining Circular Economy cities and objectives of indicators

Defining the Circular Economy in a comprehensive, understandable and relevant way has been so far quite challenging with different stakeholders providing different solutions based on different background and visions. Therefore, although the main fundamental concepts are widely recognised (reuse, reduce, recycle) different objectives and different approaches are expressed in multiple definitions.

The EU action plan for the Circular Economy characterises it as an economy "where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised" [4]. The Circular Economy is seen as an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy.

The approach of the EU action plan includes two main concepts that can be simplified as sustainability and competitiveness. Fewer emphasis is posed on other aspects that are considered equally important in other approaches and definitions such as e.g. the social aspects.

A recent article by Kirchherr, Reike and Hekkert provided an analysis of a (non comprehensive) list of 114 definitions for Circular Economy and provides the opportunity to identify common approaches and methodological frameworks. The conclusions of the analysis suggest the application of the following definition:

[3] For more details, see: https://minutes3.belfastcity.gov.uk/documents/s75208/Resourceful%20Belfast%20Update.pdf

[4] EC. 2015. Closing the loop - An EU action plan for the Circular Economy. COM(2015) 614 final. Brussels, 2.12.2015. Available at: https://ec.europa.eu/transparency/regdoc/rep/1/2015/EN/1-2015-614-EN-F1-1.PDF.

> *Circular economy is "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers.*[5]

The definition introduces the level of cities (macro level) as key players for the development of a Circular Economy framework. The role of cities is defined in the work of Prendeville et al. (based on 6 case studies) as:

> *A circular city is a city that practices CE principles to close resource loops, in partnership with the city's stakeholders (citizens, community, business and knowledge stakeholders), to realize its vision of a future-proof city.*[6]

These definitions could served as basis for discussion in the Urban Agenda partnership on Circular Economy meetings and specifically the following questions were addressed:

- Do the members of the partnership recognise themselves in those definitions? What elements are missing (or should not be there)?
- What are the boundaries of a circular city? Are they based on geographic/administrative boundaries or are far wider?
- What are the aspects of Circular Economy that can be directly influenced by local government initiatives?

In order to develop and implement a Circular Economy strategy in urban environments it is crucial to find a framework of indicators to monitor the progress and performance and, when necessary, adapt the ongoing processes. Based on the literature review, the following objectives of Circular Economy indicators can be identified:

- **Support performance assessment** – Indicators are the cornerstone of monitoring[7] as they quantify and aggregate data that helps track various elements of the Circular Economy;
- **Support policy-making** – ensure evidence-based urban planning and management of the Circular Economy;
- **Support accountability and** Circular Economy **promotion** – provide information on the progress of cities towards the Circular Economy and its benefits, which can be communicated to citizens (accountability);
- **Support improvement** – indicators can help identify key success factors and good practices on the transition to Circular Economy.

[5] Kirchherr, J., Reike, D. & Hekkert, M., 2017. Conceptualizing the Circular Economy: An analysis of 114 definitions. Resources, Conservation & Recycling.
[6] Prendevillea S., Cherimb E., Bocken N.Circular Cities: Mapping Six Cities in Transition. Environmental Innovation and Societal Transitions 26 (2018) 171–194.
[7] For example, other tools include reporting (which can be qualitative in nature) and on-site visits.

Box 1: Comments on the definition from the Workshop on CE indicators for Cities

Feedback and comments on the definition were gathered during and after the Workshop on CE indicators for Cities in Brussels on 20th of November 2018.

According to some stakeholders, the definition could consider aspects of "circular area of development" and be linked to the concept of "metabolism". As redesign is an important aspect of circular economy, this could also be included in the definition. Moreover as opposed to waste management, the definition could integrate the concept of waste prevention.

Considering that every city has a significant stock of materials, a CE approach should preserve the availability of material for as long as possible. Hence, the management of this stock should be encompassed in the definition of Circular Economy in cities. This includes securing the streams of materials and planning for the circularity of cities.

CE has not the same meaning of sustainability, but it is essential that the definition integrates this concept. For example, the application of CE should not cause an increase in GHG emissions; hence, a link to energy efficiency (or other measures limiting GHG emissions) could be made in the definition.

Furthermore, the definition should be flexible and practical, as each city is different (e.g., size, location, population) and relies on a variety of economic activities.

2 Mapping and suggested indicators

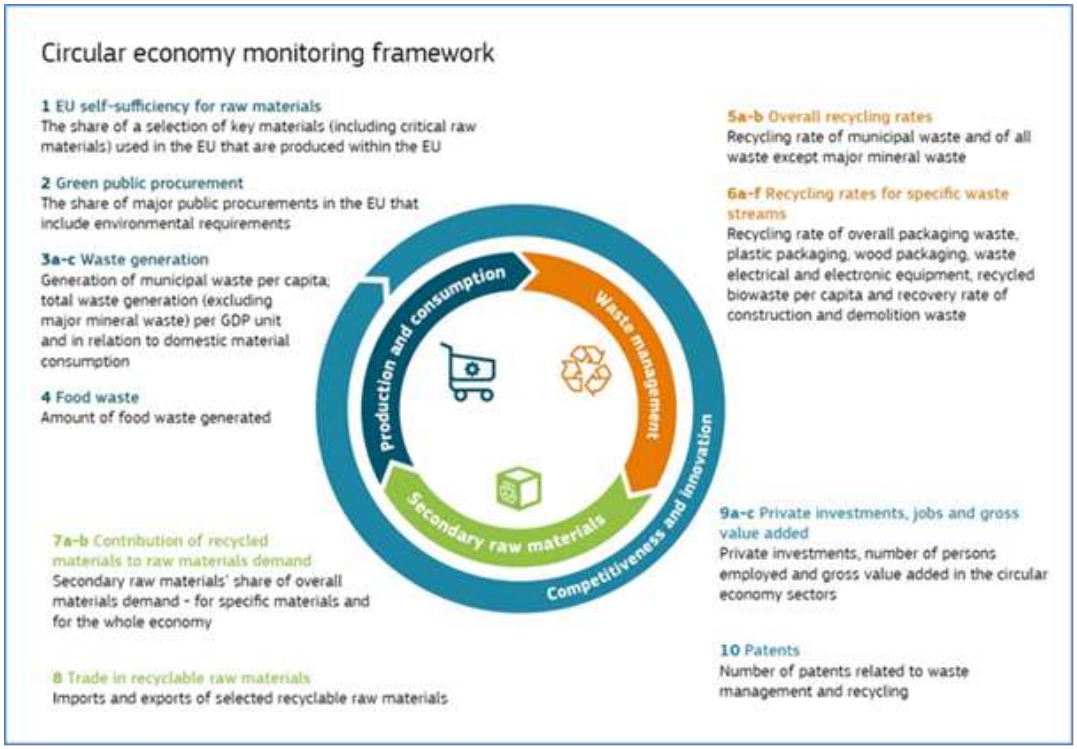
There are several existing frameworks of indicators, which are related to the Circular Economy. This section presents key guidance materials, studies, papers, and projects that include such frameworks. A long list of indicators with Circular Economy relevance has been developed as a result of the mapping exercise. The long list is presented in Annex I, while this section includes a short list of suggested indicators.

2.1 EC monitoring framework for the Circular Economy

A general monitoring framework for the Circular Economy is provided by the European Commission (EC 2018)[8] and identifies the following objectives: (1) to help understand how the various elements of the Circular Economy are developing over time; (2) help identify success factors in Member States; and (3) to assess whether sufficient action has been taken.

The general monitoring framework is composed of a set of key indicators, which capture the main elements of the Circular Economy. More specifically, it consists of 10 indicators (including sub-indicators), which are presented in the graph below.

Figure 1 Circular Economy monitoring framework



[8] EC. 2018. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a monitoring framework for the circular economy. {SWD(2018) 17 final}. Strasbourg, 16.1.2018. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A29%3AFIN

Source: EC 2018

The framework and the above indicators offer a useful reference for cities to develop Circular Economy indicators. However, there are also the following considerations:

- Not all indicators are developed to be applied at the level of cities – there is an EU-level indicator (on self-sufficiency), there are Member State level indicators (*e.g.* Trade in recyclable raw materials), and there are also municipal level indicators (*e.g.* Recycling rate of municipal waste). This means that some indicators may not be relevant at the level of cities and/or that there is no available data on these indicators at city-level.
- The choice has been made to focus on existing indicators, hence eco-innovation or industrial symbiosis has not been included.
- The framework focuses on recycling indicators, but not on re-use (which should precede recycling). Also it focuses on down-cycling rather than upcycling.
- As mentioned in the framework document, work on developing methodologies and data collections that can be used for the indicators on green public procurement and food waste is currently ongoing.
- The EC monitoring framework does not focus on eco-design (even though the Eco-design Directive is mentioned) and the collaborative economy.
- Another area that is currently not included in the framework is assessing the actual process of transition, *i.e.* there are no process indicators in the framework
- Another consequence of the focus on output/results is the absence of indicators on environmental impacts.

Suggestions on indicators[9] that could fill in these gaps are provided below.

Table 1 Suggestions on supplementary indicators

Thematic area	Indicators
Theme 1: Production and consumption	• Input of virgin materials per capita • Water used for production • Indicators on plastics prevention (including single-use) • Consumption-based GHG emissions (consumption of goods and services produced in the cities) • Number of water fountains (as a proxy for plastic waste prevention) • (Prevention of) hazardous waste generation
Theme 2: Waste management	• Indicators on separate collection • Reuse rates • Waste taken back by the industry for reuse/recycling
Theme 3: Secondary raw materials	• Trade in recyclable raw materials within cities • Reduction in imported secondary raw materials • Share of secondary or recycled materials in the raw materials • Reused public buildings and spaces (sq.m)
Theme 4: Competitiveness	• Actually applied patents at city level

[9] Most suggestions were discussed at the workshop in September.

Thematic area	Indicators
and innovation	
Industrial symbiosis Various projects (*e.g.* Sharebox)	• Number of companies involved in industrial symbiosis • Investment in symbiosis • Number of Eco-industrial parks • Million cubic metres of water saved • Million collective annual savings across firms • Tons per year in CO_2 savings • Million tonnes of landfill diversion • Million tonnes of materials recovered and reused • Billion in cost-savings • Tonnes of virgin resources saved • Tonnes of waste turned resources
Eco-design	• Activities performed by cities that encourage the implementation of eco-design measures (*e.g.* promoting extended product lifetime, ability to re-use components or recycle materials from products at end-of-life, use of re-used components and/or recycled materials in products)
Collaborative economy Source: Single market scoreboard[10]	• composite indicator representing the combined scores of the business and regulatory environment surrounding the collaborative economy • thematic indicators (on regulatory environment): accommodation, transport, finance, public administration and business support
Transition to Circular Economy in cities (process indicators)	• Waste collection planning in cities • Awareness raising – motivating stakeholders to take up CE measures • Number of pilot projects on the CE (*e.g.* on involving retailors) • Citizens involvement • Qualitative indicators on single use plastics • Actions by the city intended to encourage the procurement of articles that use secondary raw materials • Availability of a roadmap for resource management • Availability of innovative schemes for businesses at the city level, which are related to CE (not just for CO_2 emissions trading) • Extra courses for CE in universities • Awards for circular businesses (*e.g.* stamps, stickers) • Cross-learning and exchanges between cities

As a part of the establishment of the framework, Eurostat has made available a database[11] has, which provides information on most Circular Economy framework indicators. The database offers useful context information, but:

- Some indicators are not up-to-date (*e.g.* Patents related to recycling and secondary raw materials provides information until 2013, while for the indicator Circular material use rate some countries do not provide data for 2015-2016). Thus, some indicators do not provide timely information on the progress towards circularity.

[10] EC. 2018. "Collaborative Economy - Single Market Scoreboard - European Commission". 2018. Ec.Europa.Eu. Available at: http://ec.europa.eu/internal_market/scoreboard/performance_per_policy_area/collaborative-economy/index_en.htm.

[11] Eurostat. "Circular Economy Indicators - Main Tables". 2018. Ec.Europa.Eu. Available at: https://ec.europa.eu/eurostat/web/circular-economy/indicators/main-tables.

- The database has most indicators from the monitoring framework, but not all – e. g Green public procurement and food waste are not included.

2.2 Other general frameworks and relevant projects

An **In-depth report on Indicators for Sustainable Cities** was published in 2015 and revised in 2018 by the European Commission[12]. As opposed to the overall Circular Economy monitoring framework, this report focuses specifically on cities. However, its focus is on the environmental dimension of sustainability, which is described as a situation in which urban consumption matches or is below what the natural environment (such as forests, soil and water bodies) can provide (EC, 2018:6).

The report clarifies that urban sustainability indicators are tools that allow gauging the socio-economic and environmental impact of current urban designs, *e.g.*: infrastructures, policies, waste disposal systems, pollution and access to services by citizens. It provides definitions of indicators and their objectives, describes indicator frameworks and makes references to various useful tools. Driving science-based urban planning and management is among the objectives of indicators, which are identified in the report.

The report does not focus on the Circular Economy, but rather reviews sustainability in a broad and mostly environmental sense. The mapping of frameworks does not provide instructions on which frameworks and indicators have the highest value for cities in terms of assessing their Circular Economy objectives. Furthermore, most indicator frameworks offer aggregate indicators, which may be difficult to disentangle (*e.g.* governance).

Nevertheless, the following indicators and frameworks, which are mapped by the In-depth report, can be of value when defining Circular Economy indicators:

Table 2 Indicators and frameworks with Circular Economy relevance

Indicator	Indicator framework	Rationale
Waste intensity	City Blueprints, EEA Urban Metabolism Framework	Useful indicators on waste
Recycling	City Blueprints, EEA Urban Metabolism Framework	Useful indicators on waste
Waste and land use	European Green City Index	Useful indicators on waste
Waste and CE	European Green Leaf Award	Useful indicators on waste
Overall indicators • Recycling rate (Percentage diverted from waste stream) • Volume of solid waste generated	Indicators for Sustainability[13] Barcelona Agenda 21 Indicators Dublin Development Plan	Waste indicators are directly linked to the CE, while some process indicators can be considered (*e.g.* organisations with certification and

[12] EC. 2018. Indicators for sustainable cities. In-depth Report. Available at: http://ec.europa.eu/environment/integration/research/newsalert/pdf/indicators_for_sustainable_cities_IR12_en.pdf.

[13] Sustainable Cities International. 2012. Indicators for Sustainability - How cities are monitoring and evaluating their success. Available at: https://sustainablecities.net/wp-content/uploads/2015/10/indicators-for-sustainability-intl-case-studies-final.pdf.

Indicator	Indicator framework	Rationale
Barcelona case study: • 14. Generation of urban solid waste • 15. Collection of organic material • 16. Selective waste collection • 21. Number of organisations with environmental certification • 22. Number of schools that participate in environmental education projects Dublin case study: • % of waste recycled • Tonne of waste per capita per year • Tonnes of (methane producing) organic waste diverted from landfill	2011-2017	education projects)
• Diversion of Landfill of biodegradable waste • Municipal waste generated per capita • Municipal Waste recycling rate • Domestic material consumption • Products promoting sustainability - green purchasing of local authority • Share of Green Public Procurement • Number of organisations with registered environmental management systems according to EMAS and/or ISO 14001	Reference Framework for Sustainable Cities (http://app.rfsc.eu/)	Very useful frameworks of indicators that are directly and indirectly linked to the CE, which also include links to objectives, background information and metrics

Indicator	Indicator framework	Rationale
• Annual amount of solid waste (domestic and commercial) • Annual amount of solid waste (domestic and commercial) processed by landfill sites • Annual amount of solid waste (domestic and commercial) processed by incinerators • Annual amount of solid waste (domestic and commercial) that is recycled • Annual amount of solid waste (domestic and commercial) given to other disposal units • Share of the urban waste water load (in population equivalents) treated according to the applicable standard -% [urb_cenv] • Municipal waste generated (domestic and commercial), total - 1000 t [urb_cenv]	Urban Audit Reference Guide[14] Environment - cities and greater cities [urb_cenv]	Useful indicators on waste
• Amount of municipal waste produced • Municipal waste processed according to differentiated refuse collection schemes • Green public procurement procedures and purchasing • EMAS and ISO 14001 certification of public authorities • Level of implementation of Agenda 21 processes	Urban Ecosystem Europe[15]	Useful indicators on waste and governance
• Tonnes of waste disposed of per inhabitant and per year (building and demolition waste, industrial waste, domestic waste, retail and service waste)	Urban Sustainability Indicators	Useful indicators on waste
• Industrial waste recycling • Number of environmental professionals • Environmental funding	China Urban Sustainability Index	• Useful indicator on waste • It could be interesting to assess the number of professionals involved in the CE • The third indicator can be

[14] EC. 2018. Indicators for sustainable cities. In-depth Report. Available at: http://ec.europa.eu/environment/integration/research/newsalert/pdf/indicators_for_sustainable_cities_IR12_en.pdf.

[15] Ambiente Italia Instituto di Ricerche .Urban Ecosystem Europe - An integrated assessment on the sustainability of 32 European cities. Available at: http://www.dexia.com/EN/journalist/press_releases/Documents/20080201_urban_ecosystem_UK.pdf.

Indicator	Indicator framework	Rationale
		transformed into a process indicator on CE funding

Further to the above frameworks, mapped by the In-depth report on Indicators for Sustainable Cities, this section also adds other frameworks and indicators developed by: CITYkeys, Ellen McArthur Foundation, OECD, and the city of London among others.

The **Ellen McArthur Foundation** led the Circularity Indicators Project, which provides companies with a methodology and tools to assess how well a product or company performs in the context of a Circular Economy. They developed seven indicators that target companies and focus on the production aspects, *e.g.*: Material Circularity Indicator for products (The MCI gives a value between 0 and 1 where higher values indicate a higher circularity) [16] calculated with at least 4 different inputs, among them the Efficiency of recycling.[17] The indicators are relevant to the CE, but might be difficult to apply at city level.

The **OECD** Green Growth indicators framework (updated in 2017) includes approximately 30 indicators, which are meant to help countries assess and compare their progress towards four main objectives: establishing a low-carbon, resource-efficient economy; maintaining the natural asset base; improving people's quality of life; and implementing appropriate policy to realise the economic opportunities of green growth. These indicators address the national level mainly and are not dedicated to the Circular Economy. Nevertheless, some indicators (presented below) can also be helpful to monitor Circular Economy and they could be adapted to fit to the municipal level.

Table 3 OECD indicators

Indicator	Rationale
Municipal waste, defined as household and similar waste collected by or on behalf of municipalities, and originated from household, offices and small businesses	Useful waste management indicator
Material recovery (includes recovery for recycling and composting)	Material recovery is linked to the CE
Landfill rates of municipal waste, defined as the amounts of municipal waste disposed at landfills as a percentage of amounts treated	The expectation is that landfill rates are decreasing
Landfill tax rates, the tax levied per tonne of municipal waste disposed in landfills	Tax rates vary depending on waste types: maximum tax rates apply to waste that could be easily recovered (such as recyclable and compostable waste. Final waste is usually subject to a lower rate.

[16] Ellen MacArthur Foundation, and Granta Design, 2015. Circularity Indicators: An Approach to Measure Circularity. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/insight/Circularity-Indicators_Non-Technical-Case-Studies_May2015.pdf .

[17] Ellen MacArthur Foundation, and Granta Design, 2015. Project Overview: An Approach to Measuring Circularity. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/insight/Circularity-Indicators_Project-Overview_May2015.pdf

Public energy technology RD&D expenditures directed at "renewable energy " and "fossil fuel energy", expressed as percentages of total public energy RD&D	The indicator can be moved into the direction of CE
Technology development: the number of inventions (simple patent families) developed by a country's inventors, independent of the jurisdictions where a patent application has been registered (*i.e.* all known patent families worldwide are considered)	It would be difficult to tweak this level at city level
Employment and value added in selected environmental protection activities expressed as a percentage of total; sewerage, waste management and remediation	It could be interesting to see at the municipal level the employment and value added in the waste management sector
Share of environmentally related tax revenue, expressed as a percentage of total tax revenue and compared to GDP and to labour tax revenue	It allows the identification of the structure of taxes, which can be relevant.

Source: OECD Green Growth indicators 2017[18]

The **ESPON CIRCTER**[19] project – Circular Economy and Territorial Consequences aims to provide information on the territorial dimension of the Circular Economy transition and to provide evidence on local and regional patterns and flows of materials, including resources and waste. The available inception report presents a set of 13 indicators divided into 2 categories: (1) indicators for material input and (2) waste indicators. The focus is on regional and national level, but possibly some of the indicators below can be adapted to cities.

Table 4 CIRCTER indicators

Indicator	Rationale
Material consumption per capita	Shows the material consumption on a per capita base and is suitable for benchmark analyses of countries or regions.
Use of the local natural endowment	A high share of domestic extraction used (DEU) on domestic material consumption (DMC) indicate a higher autarky
Development of resource consumption over time	The indicator shows trends in resource consumption, but it should be specified.
Total waste generated per cap	Shows how much waste is generated on a per capita base
Different waste categories per cap	The categories show how much of a particular waste streams occur on a per capita base
Waste intensity per NACE activity	Illustrates sectoral waste intensity
Recycling or recovery rate of different waste streams	A useful recycling indicator

[18] OECD. 2017. Green Growth Indicators 2017. Paris. Available at: https://read.oecd-ilibrary.org/environment/green-growth-indicators-2017_9789264268586-en#page137.

[19] More information on the project is available at: https://www.espon.eu/circular-economy.

Breakdown of waste streams by different treatment options	A useful waste management indicator, but ideally it should be specified.

Source: ESPON Project CIRCTER

CITYkeys is a project funded under Horizon 2020 programme, which involves research institutes (VTT, AIT, and TNO) in cooperation with five cities – Rotterdam, Tampere, Vienna, Zagreb and Zaragoza and EUROCITIES. The project developed and validated, with the aid of cities, key performance indicators and data collection procedures for the common and transparent monitoring as well as the comparability of smart city solutions across European cities. The partners developed 73 Key Performance Indicators for Sustainable Digital Multiservice Cities, which to some extent can be used for Circular Economy transition in cities. Suggestions on indicators that can be related to the Circular Economy are presented below.

Table 5 CITYkeys indicators

Indicator	Rationale
Environmental education (% of schools)	The indicator can be adjusted to the CE, if the education includes awareness of the CE principles
Grey and rain water use (% of houses, houses equipped to reuse grey and rain water)	The indicator could potentially be applied to office buildings
Recycling rate (% per tonnes, of the city's solid waste that is recycled)	Waste management
Municipal solid waste (t/cap/year)	Waste management
Share of certified companies (% of companies). Share of companies based in the city holding an ISO 14001 certificate	Companies which comply with norms for environmental management which include waste management.

Source: CITYkeys and Eurocities - Key Performance Indicators for Sustainable Digital Multiservice Cities

The **Synergic Circular Economy across European Regions (SCREEN)** project is funded under Horizon 2020 programme and involves 18 partners representing 17 regions belonging to 12 European Countries. It aims to develop a replicable systemic approach towards the transition to Circular Economy in EU regions within the context of their Smart Specialization Strategies. The project led to the development of 9 assessment criteria[20] for Circular Economy projects based on the explanation given in the EU Circular Economy action plan.[21] The focus is on Circular Economy projects, but possibly some of the indicators below can be adapted to cities.

Table 6 SCREEN indicators

Indicator	Rationale
Re-Use, Re-Manufacturing, Refurbishment	The indicator shows the prolongation of the life of a certain product that otherwise will be disposed

[20] SCREEN. 2018. "SCREEN Laboratory". Screen-Lab.Eu. http://www.screen-lab.eu/Questionnaire.html.

[21] EC. 2015. Closing the loop - An EU action plan for the Circular Economy. COM(2015) 614 final. Brussels, 2.12.2015. Available at: https://ec.europa.eu/transparency/regdoc/rep/1/2015/EN/1-2015-614-EN-F1-1.PDF.

Mass of waste resources recovered and re-introduced in a production cycle as secondary raw material	The indicator shows that the new process generates waste that can be re-used in the same process or in another production process
Project promoting waste recycling	Promotional campaign with a specific target producing a specific waste
Net balance of jobs	Number of new jobs created by the CE project, minus the number of jobs lost in the previous linear process

Source: VELTHA Project SCREEN

The **CIRCULAR IMPACTS project** is funded under the Horizon 2020 program and involves 3 institutions (CEPS, Ecologic Institute and Wageningen University & Research). The project aims to develop an assessment based on data and indicators of the macro-economic, societal and environmental impacts of a successful transition to a Circular Economy. Together, the partners developed an online library with evidence resources useful for impact assessments on the transition to a Circular Economy.[22]

On a regional level, **Flanders (Belgium)** made an inventory of Circular Economy indicators that are relevant to monitor the transition to a Circular Economy and to measure effects of new policy and trends. The scope of indicators (presented in the *Short-term Assignment, Indicators for a Circular Economy*) varies largely, *e.g.* material flow indicators can focus on global figures, but also on a specific substance content in a component.[23] Though the set of indicators aims to describe the regional level, some of them could be adapted to the city level.

This report was part of the idea generation phase in a project dedicated to develop a circular economy monitor for Flanders, carried out by the Policy Research Centre Circular Economy funded by the Flemish administration. With respect to this monitor, the elaborated underpinning concept has been recently published (ce-centre.be). The approach is to measure circular economy achievements in the fulfilment of societal needs by displaying the material realities. While the monitor is not available yet, the exemplary elaboration of 'mobility' as a system in the paper shows how this could work in practice, by showing for instance how much vehicles are needed in relation to the amount of kilometres travelled. When for instance car-sharing would desirably develop into the direction of reducing the amount of kilometres travelled in privately owned cars, this will be directly visible in the monitor. The approach of societal needs is expected be interesting as well at the city level, because it aligns well with the perspective of policy makers and allows a relatively fast feedback on policy.

Table 7 Flanders - Inventory of Circular Economy indicators

Indicator	Rationale
RMC - Raw material consumption	The RMC measures the global material use associated with domestic production and consumption activities, equalling DEU (domestic

[22] CIRCULAR IMPACTS. 2018. "Indicators | CIRCULAR IMPACTS". Circular-Impacts.Eu. Available at: https://circular-impacts.eu/type-evidence/indicators.

[23] Vercalsteren An (VITO), Christis Maarten (VITO), Van Hoof Veronique (VITO). 2018. "Short-Term Assignment, Indicators for a Circular Economy". Vlaanderen-Circulair.Be. Available at: https://vlaanderen-circulair.be/en/summa-ce-centre/publications/indicators-for-a-circular-economy

	extraction used) plus imports in RME (raw material equivalents) minus export in RME.
MFM(+) - (expanded) Material flow monitor	The material flow monitor is a set of indicators providing insight into the physical material flows (in kilos) to, from and within an economy.
Resource footprint indicator based on Cumulative Energy Extracted from the Natural Environment (CEENE)	It allows one to calculate resource footprints for products or services consumed in different countries as the exergy extracted from nature.
Cyclical material use rate	The cyclical material use rate is an indicator providing the share of cyclical use of materials in total use of materials; the latter is defined as the sum of direct material input plus the cyclical use of materials.
EOL-RIR (End of Life Recycling Input Rate)	The EOL-RIR is an indication for Recycling's contribution to meeting materials demand.
Recycling rates	The recycling rate is the tonnage recycled from a specific waste stream divided by the total specified waste arising, including recycling, composting and anaerobic digestion.
Recyclability benefit rate	Recyclability Benefit rate is an index for the prioritisation of resources based on the potential benefits that can be achieved from their recycling
(Energy) Recoverability benefit rate	Energy Recoverability Benefit rate is an index for the prioritisation of resources based on the potential benefits that can be achieved from their energy recovery
Trade in secondary raw materials	Trade in secondary raw materials measures the movements of waste, regarded as a potential valuable resource, across regional, national and European borders.
Waste generation	Waste generation measures the amount of waste generated per year
Waste electrical & electronic equipment (WEEE) management	This indicators shows the amount of WEEE collected, recycled and reused.
Private investment, jobs and GVA: recycling sector, repair and reuse sector	Gross investment in tangible goods, number of persons employed and value added at factor costs created in the recycling sector; repair and reuse sector.
MSA – Material system analysis	The MSA measures bulk material flows in a CE. It is a socio-metabolic approach to assess the circularity of global material flows.

Source: "Indicators for a Circular Economy". 2018. Vlaanderen-Circulair.Be

2.3 Existing city-level Circular Economy frameworks

On a city level, the **London** Waste and Recycling Board (LWARB) commissioned a study for the development of metrics that could be used to measure London's future progress towards becoming a more circular city. It includes the following key thematic areas: Resource productivity and consumption; Waste generation and recycling; and Business and employment opportunities in the CE. The report[24] presents indicators that were quantified, their baselines, and the change in values over time. Furthermore, it assesses their relative strengths and limitations. The framework includes the following indicators:

Table 8 London – Circular Economy indicators

Thematic area	Indicators
Consumption indicators	• Circularity of Industry Consumption (ratio of spending on services to spending on goods) • Circularity of Household Consumption (ratio of spending on services to spending on goods)
Material intensity and carbon intensity indicators	• Material intensity per unit of GVA (tonnes/per £million), sum of all materials • Scope 3 emissions (consumption-based methodology), $MtCO_2e$
Municipal waste	• Waste intensity per household (tonnes of waste per household) • Management of local authority waste, share of waste to the following categories: landfill, incinerated, recycled, other
Industry waste by sector	• All waste for all industrial sectors (tonnes of waste)
Jobs and GVA	• Direct jobs in the CE (identified by 5-digit SIC-code) • Indirect jobs in the CE (jobs dependent on CE, I/O method) • Share of London's GVA from CE activity
Enabling metrics	• CE procurements • Number of business supported • Number of demonstration projects • Number of CE courses PhDs/university courses, patents

Source: LWARB (2018)

The city of **Brussels** has developed a strategy toward Circular Economy transition. Through the PREC, the government of the Brussels-Capital Region defines a framework to "encourage the transformation of a linear economy (extract - produce-consume-discard) into a Circular Economy (recover-produce - consume-re-use) within the Brussels-Capital Region". In this context, they developed a set of indicators to monitor Circular Economy transition.[25]

Table 9 Brussels - Circular Economy indicators

Thematic area	Indicators
Process indicators	• Number of legislative and normative barriers identified and resolved • Number of legislative and normative incentives created

[24] LWARB. 2018. Measuring London's progress towards becoming a more circular city. Cambridge Econometrics. Final Report.
[25] Brussels. 2016. Programme régional en économie circulaire 2016 – 2020 Mobiliser les ressources et minimiser les richesses perdues: Pour une économie régionale innovante. Available at : http://document.environnement.brussels/opac_css/elecfile/PROG_160308_PREC_DEF_FR

Thematic area	Indicators
	• Number of people trained in CE trades • Number of students trained in CE occupations • Number of pilot cases set up via calls for projects / living lab • Number of seminars organized on the CE under the PREC • Number of economic operators sensitized on CE • Budget amount allocated to calls for projects / living lab made / implemented and number companies having benefited. • Budget amount and number of pilot public markets in CE developed in Brussels-Capital Region • Number of companies informed / aware of the opportunities of the Brussels public markets • Number of new neighbourhoods incorporating the principles of the CE
Competitiveness / Investment	• Number of enterprises receiving financial support in connection with the CE • Amount of financial aid granted to companies in connection with the CE • Number of economic operators accompanied in CE
Jobs and GVA	• Number of job-seekers put to work following training developed in the context of PREC

Source: Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)

Circle Economy implemented a **City Circle Scan for the city of Amsterdam.** The assessment of the circularity of the city of Amsterdam is based on three core indicators: value preservation, economic impact and ecological impact. These core indicators (supported by other indicators) give an initial idea of how circularity could be monitor at the city-level.[26]

Table 10 City Circle Scan for the city of Amsterdam – Circular Economy indicators

Core indicator	Supporting indicators
Value preservation	• Raw material efficiency: indicates possible waste reduction in production of goods, measured in kilograms of waste per €1,000 output • Use of renewable resources: the percentage of imports (net and domestic) consisting of biomass compared to total imports
Economic impact	• Gross Value Added per person: the economic value in € per person • Circular services: the percentage of services - related to the CE - compared with the Gross Value Added
Ecological impact	• Environmental costs: the costs of exhaustion, water pollution, CO_2-emissions, toxicity and land use in € per kilogram • CO_2 emission: the amount of carbon dioxide which is released into the atmosphere in kilograms of CO_2 per person

Source: Circle Economy - City Circle Scan for the city of Amsterdam

[26] Circle economy. 2016. Circular Amsterdam - A vision and action agenda for the city and metropolitan area. Available at: https://www.circle-economy.com/wp-content/uploads/2016/04/Circular-Amsterdam-EN-small-210316.pdf

Outside of Europe, the city of **Melbourne** commissioned an assessment of the city services and quality of life. The assessment has been made by the International Organization for Standardization following the **ISO 37120** which establishes definitions and methodologies for a set of city indicators to steer and measure delivery of city services and quality of life.[27] Although this is not their primary role, some of the indicators used can be used to address the Circular Economy.

Table 11 Melbourne / ISO 37120 - Indicators

Thematic area	Indicators
Economy	• Number of new patents per 100 000 population per year
Energy	• Energy consumption of public buildings per year (kWh/m²) • The percentage of total energy derived from renewable sources, as a share of the city's total energy consumption
Waste	• Percentage of city population with regular solid waste collection (residential) • Total collected municipal solid waste per capita • Percentage of the city's solid waste that is recycled • Percentage of the city's solid waste that is disposed of in a sanitary landfill • Percentage of the city's solid waste that is disposed of in an incinerator • Percentage of the city's solid waste that is burned openly • Percentage of the city's solid waste that is disposed of in an open dump • Percentage of the city's solid waste that is disposed of by other means • Hazardous Waste Generation per capita (tonnes) • Percentage of the city's hazardous waste that is recycled
Wastewater and water	• Percentage of city population served by wastewater collection • Percentage of the city's wastewater that has received no treatment • Percentage of the city's wastewater receiving primary treatment • Percentage of the city's wastewater receiving secondary treatment • Percentage of the city's wastewater receiving tertiary treatment • Percentage of water loss (unaccounted for water)

Source: Melbourne / ISO 37120

[27] ISO. 2015. ISO 37120 Sustainable development of communities - Indicators for city services and quality of life. City of Melbourne. Available at: https://data.melbourne.vic.gov.au/api/views/e6er-4cb3/files/knfQXAsM64HVBqEqe0Ha4bF3zddp8nRp09gjiswDjGk?download=true&filename=ISO_37120_2014(en)%20(3).pdf

2.4 Suggested indicators

Feedback and comments were gathered during and after the Workshop on CE indicators for Cities, which was held in Brussels on 20th of November 2018. Stakeholders were asked to assess the indicators of the list in Annex 1 according to the following criteria:

- **Core/additional indicator (2 = core; 1 = additional, 0 = not relevant)** Do you think the indicator is relevant for measuring Circular Economy in a city?
- **Data availability and quality at city level (from 2 = high availability,to 0= no/scarse availability):** Is information available (or could be available) at the city level?
- **Influence of local authority on the indicator (from 2= high influence, to 0= no/very limited influence):** To what extent can a local authority influence the activity measured by a specific indicator?

The results of the mapping and consultation exercises (See also the limitations in Text box 2) are presented in Table 12. It presents indicators in line with the EC monitoring framework for the Circular Economy (see Section 2.1). All of the indicators are linked to the extent possible to the simplified model of the circular economy for materials and energy (presented on the figure below), which was developed by the European Environment Agency[28].

Figure 2 Simplified model of the circular economy for materials and energy

Source: EEA 2016

[28] EEA. 2016. Circular economy in Europe. Developing the knowledge base. EEA Report No 2/2016. Available at: https://www.eea.europa.eu/publications/circular-economy-in-europe

Furthermore, the indicators in the table are categorised according to a simple typology:

- *Process indicators* – indicators, which are linked to activities performed by cities in relation to supporting the transition to a Circular Economy (CE). For example, Communication campaigns on increasing the recycling/repair/reuse of Waste electrical and electronic equipment (WEEE);
- *Outcome indicators* – indicators that are linked to some positive changes related to different elements of the CE. For example, increased rate of recycling of WEEE;
- *Context indicators* – indicators that help contextualise (i.e. put into perspective) changes in the CE. For example, the indicator Annual amount of solid waste would support understanding the overall trends in waste.

Table 12 also includes the source of the indicator, indication on possible measurement units, and initial data availability (based mostly on the feedback received from different stakeholders).

Box 2: Suggested indicators - limitations

Though many indicators (Annex 1) have been collected through the mapping exercise, some of them are not needed or not on city scope. Moreover, the indicators should also be relevant in terms of time, i.e., short-, medium-, long-term. This timescale is part of the understanding of the indicators especially concerning their necessity. Moreover, though relevance has an added-value for the selection of the indicators, cities differ in their needs and understanding on what is a relevant indicator.

Not all the participants to the consultation process within the study were representative of cities. Hence, the input has been taken with this caveat. Also, the cities which provided input are large cities; their point of view vary between them and might differ from cities with a different size.

Based on the feedback received table 12 provides a list of indicators, which received high scores for the above mentioned criteria. However, additional indicators were added in order to cover the thematic areas of the EC monitoring framework and to ensure reasonable balance between the different groups of indicators.

Last, but not least, it should be noted that considering the limitations of the mapping process, **the suggested indicators are only meant to support discussions and further work on CE indicators at city level**.

Table 12 List of suggested indicators

Thematic area	Category	Indicators	Indicator type (process, outcome, context)	Link to conceptual elements	Comments (units of measurement and data availability)	Framework
Theme 1: Production and consumption	Self-sufficiency for raw materials	Input of virgin materials per capita	Outcome	Production and distribution	Unit: Tons per capita Data: Very low / no data available	Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		Water used for production processes and domestic water consumption	Outcome	Production and distribution	Unit: Cubic meters Data: Low availability	Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		Organisations that have implemented an environmental management system (EMAS, Ökoprofit, QuB, ISO 14001 certification)	Outcome	Production and distribution / Eco-design	Unit: Number or share Data: Medium availability	CIRCTER paper
	Green Public procurement	Share of major procurement that includes environmental requirements	Process	Consumption and Stock	Unit: % Data: Medium availability	EC monitoring framework for the Circular Economy
		CE/waste prevention criteria developed in guidelines for procurement	Process	Consumption and Stock	Unit: Qualitative (Yes/No) Data: High availability	CIRCTER paper
	Waste generation	Annual amount of solid waste (domestic and commercial)	Context	Waste	Unit: Tonnes of waste (per capita) Data: High availability	Urban Audit Reference Guide / Environment – cities and greater cities Eurostat [urb_cenv] Eurostat [cei_pc031]
		All waste for all industry sectors	Outcome	Waste	Unit: Tonnes of waste Data: Medium availability	London – Circular Economy indicators
		Waste Electrical & Electronic Equipment (WEEE) Generation	Outcome	Waste	Unit: Tonnes of waste collected Data: Medium availability	Flanders - Inventory of Circular Economy indicators Eurostat [env_waselee]
		Hazardous Waste	Outcome	Waste	Unit: Tonnes of waste	Melbourne / ISO 37120

		Generation per capita (tonnes)			Data: Medium availability	
		Level of public awareness for circular economy and waste prevention	Outcome	Waste / Consumption and Stock	Unit: % of people Data: Low availability (requires surveys)	CIRCTER paper
		Communication measures (campaign, provision of information, events for the public/companies) on circular transformations and waste prevention	Process	Waste / Consumption and Stock	Unit: Number Data: Medium availability	CIRCTER paper
	Food waste generation	Generation of food waste	Outcome	Waste	Unit: total food waste generated (for households), or total food waste collected by separate collection, or share of food waste in residual waste Data: Very low / no data available	EC monitoring framework for the Circular Economy
		Initiatives/awareness campaigns at city level for the reduction of food waste generation	Process	Waste	Unit: Number Data: Medium availability	Various initiatives/projects, including the CIRCTER paper
Theme 2: Waste management	Overall recycling rates	Recycling rate (% of the city's solid waste that is recycled)	Context	Recycling	Unit: % (of weight); If data allow it: % of waste upcycled and/or % of waste downcycled Data: High availability	Eurocities - Key Performance Indicators for Sustainable Digital Multiservice Cities Eurostat: sdg_11_60
	Recycling rates for specific waste streams	Breakdown of waste streams[29] by different treatment options	Outcome	Recycling	Unit: % (of weight) E.g.: % of construction and demolition mineral waste recycled; kg per capita recycled biowaste; tonnes of hazardous waste treated	CIRCTER Indicators Eurostat: cei_wm040, cei_wm030

[29] An option to consider, in case of data availability, is to have a breakdown per material rather than specific stream.

					Data: Medium availability	
		Waste electrical and electronic equipment (WEEE) by waste management operations	Outcome	Recycling (recovery, reuse)	Unit: Recovery (tonne/percentage), Recycling and reuse (tonne/percentage), Reuse (tonne/percentage) Data: Medium availability – available from Eurostat, but not at city level	Eurostat [env_waselee]
		Diversion of landfill of biodegradable waste	Outcome	Landfill minimisation	Unit: Tonnes of waste Data: Low availability	Reference Framework for Sustainable Cities (http://app.rfsc.eu/)
		Availability of a strategy for waste management	Process	Recycling	Unit: Qualitative (Y/N) Data: Medium availability	Workshops
Theme 3: Secondary raw materials	Contribution of recycled materials to raw materials demand	Contribution of recycled materials to raw materials demand - End-of-life recycling input rates	Context	Materials	Unit: % Data: Low availability	EC monitoring framework for the Circular Economy Eurostat: cei_srm010
		Circular material use rate in local industrial/economic processes	Outcome	Materials	Unit: % of total material use Data: Very low / no data	EC monitoring framework for the Circular Economy Eurostat: cei_srm030
		Activities performed by cities that encourage the implementation of eco-design measures	Process	Eco-design	Unit: Number of measures (e.g. promoting extended product lifetime, ability to re-use components or recycle materials from products at end-of-life, use of re-used components and/or recycled materials in products) Data: Medium availability	Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		Organisations that are implementing LCA schemes, EPR, Eco-label etc..	Outcome	Production and distribution / Eco-design	Unit: Number or share Data: Medium availability	Adapted from CIRCTER paper
Theme 4: Competitiveness and innovation	Patents	Patents related to recycling and secondary raw materials	Context	Materials	Unit: Number Data: N/A	EC monitoring framework for the Circular Economy

						Eurostat: cei_cie020
	Private investments, jobs and gross value added in Circular Economy business	Direct jobs in CE (identify by 5-digit SIC-code)	Context	All sectors	Unit: Number / FTEs Data: Medium availability	London – Circular Economy indicators Eurostat: cei_cie010
		Number of circular economy businesses offered business support	Process	All sectors	Unit: Number Data: High availability	Circle Economy - City Circle Scan for the city of Amsterdam
		Budget amount allocated to calls for projects on CE	Process	All sectors	Unit: Number Data: High availability	Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		Number of pilot projects on CE	Process	All sectors	Unit: Number Data: High availability	Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		Number of children and/or students trained in CE aspects and/or occupations	Process	All sectors	Unit: Number of children (school education) and/or students (higher education) Data: Medium availability	Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
Overarching indicators	-	Greenhouse gases	Context	Emissions	Unit: thousand tonnes (E.g. in industrial processes and product use, waste management) Data: Low availability	Circle Economy - City Circle Scan for the city of Amsterdam Eurostat: [env_air_gge]
		Availability of a CE strategy at city level	Process	All sectors	Unit: Qualitative (Yes/No) Data: High availability	Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)

3 Next steps and collaboration opportunities

3.1 Possible follow-up actions

In addition to collaboration with other initiatives (see the next sections), two possible follow-up actions could be explored: development of a toolkit and empirical work on indicators between cities. These possibilities, which are not mutually exclusive, are presented below.

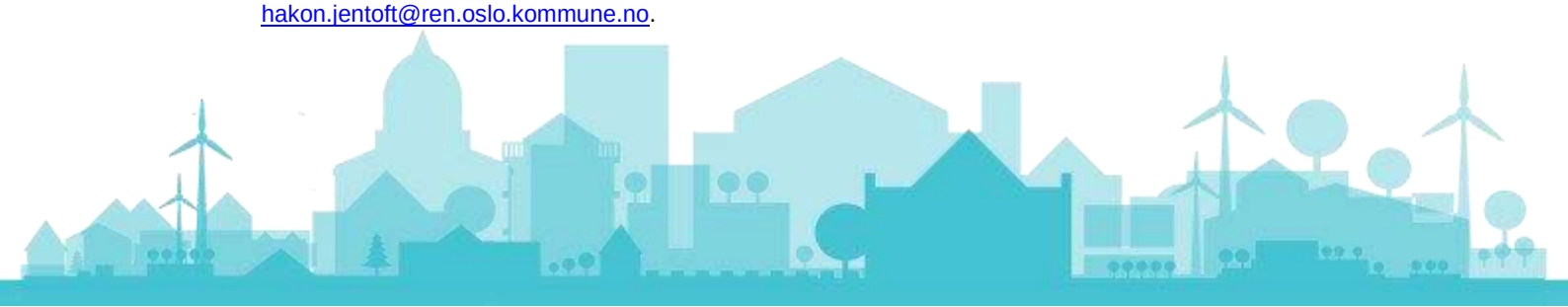
To implement the set of suggested indicators **a toolkit** could be created. The toolkit could consider the work performed under this study and build on it by:

- *Considering differences between cities* - It's interesting to think about how the data across cities would be interpreted. One would imagine big differences between cities that have a large manufacturing base as compared to a city with a large service sector, a city with a lot of construction work going on compared to one where few buildings are being constructed. It makes setting targets across cities difficult. Tourism flows also affect cities differently – significant increases in tourism, particularly in smaller cities, may have noticeable effects on the consumption and waste management of cities;
- *Further considering accessibility of data* - the source and accessibility of the data is key and should be clearly identified: some of the data is in the hand of various municipal departments, others are in the hands of local utilities, both being public authorities, but other indicators come from the private sector (patents, etc.);
- *Preparing a Manual on indicators* - the manual could include further operationalisation of the indicators suggested in this paper, by adding definitions of indicators, other CE objectives linked to them, more indicators, providing examples of the application of the indicators by cities.

To create this toolkit, funding could be sought, and collaborations pursued.

Another option is to focus on several core indicators applicable across cities (as suggested during the study, for example 10 indicators from the indicators in Table 12) and to compare their current implementation, relevance, data availability, drivers, and challenges across cities taking part in the Urban Agenda Partnership on Circular Economy. Such **a collaboration between cities** would allow going beyond the theoretical side of indicators and the provision of case studies and best practices in the actual use of indicators. When (and if) common understanding about the application of the indicators is ensured between the participating cities, comparisons can be provided in order to derive lessons learned on which indicators have the highest value of measuring success in CE actions in cities.

Thus, a next step for the partnership could be to invite participants to a new workshop to establish a project/initiative to test out several of the different indicators proposed in this note. The workshop and a project should be carried out in cooperation with other organisations. All interested stakeholders are invited to give feedback to this note and to the next step by sending an email to hakon.jentoft@ren.oslo.kommune.no.



3.2 Collaboration with ESPON

The possible collaboration with the CIRCTER project (presented briefly in section 2.2) has been proposed after the September 2018 workshop and has been discussed on several occasions. As mentioned, the main objective of the project is to provide evidence on the territorial dimension of the transition towards a Circular Economy and to provide evidence on local and regional patterns and flows of materials, including resources and waste. Thus, there have been clear opportunities for synergies between the Partnership on Circular Economy and the ESPON project.

Building upon the work performed for this issues paper (Step 1) and the feedback from the November workshop (Step 2), the collaboration with the CIRCTER project focused on the following elements:

1) establish an analytical framework of city-level Circular Economy indicators that highlights a basis for a hierarchy of indicators based on an analysis of the links between objectives and indicators;
2) provide suggestions on possible governance indicators that go beyond status quo and waste based figures and focus on meaningful good governance;
3) highlight the territorial specificities that need to be considered when designing indicator systems on Circular Economy, e.g. with regard to large and small cities, remote and close cities, richer and poorer cities;
4) discuss considerations on data availability for specific CE indicators at city level.

The contribution from CIRCTER was synthesized in a stand-alone report, which is to be included as an Annex to the Final Report of the CIRCTER project (due for the first week of May 2019).

3.3 Future collaboration with other initiatives

As identified and shown in this note, several initiatives are taken to develop a set of indicators to use for cities in their transition towards a circular economy. Dedicated workshops have been extremely valuable for this action in terms of getting feedback on the work. At the same time, **indicators based on the UN Sustainable Development Goals are also under development**. Several of these indicators are tried out in practises in cities in Europe. As mentioned above, moving forward, it could be looked into whether or how to link the indicators closer with the Sustainable Development Goals, to highlight some key indicators to make it easier for cities to focus or choose them, and to potentially ask those cities who are Partners to do a ‘test run’ using the indicators.

The partnership has been informed of the **OECD working on Cities Circular Economy indicators**. They have collected more than 400 indicators used to measure CE. They have done a preliminary selection of quantitative indicators by sector (water, waste, energy, urban, material, air, demographics). Their aim is to create 2 tools to measure how circular cities are: a circular economy scoreboard and a self-assessment tool. The output of their project would be a synthesis report, a standalone case study (report) for each city/region, 2 international workshops and consensus-based indicator framework and self-assessment tool. A collaboration between the OECD and the

Urban Partnership could maximise synergies, and complement existing findings. Indeed, cities of the Urban Partnership could be used for case studies and both sets of indicators could complement each other.

Collaboration with the European Institute of Innovation and Technology's **'Knowledge and Innovation Communities' (KIC)** could also be explored. These partnerships aim to bring together businesses, research centres, and universities in order to address different societal challenges, including climate change, manufacturing, raw materials, and sustainable energy[30]. Considering the link of circular economy to these challenges and the fact that the KICs are dealing with issues at city level, collaborating with them is another opportunity that can be pursued.

[30] The list of KICs is available at: https://eit.europa.eu/activities/innovation-communities

Annex I: A long list of Circular Economy indicators

Table 13 Original list of Circular Economy indicators and link to the thematic areas of the Circular Economy monitoring framework[31]

Thematic area	Category	Indicators	Framework (if relevant)
Theme 1: Production and consumption	• Self-sufficiency for raw materials	• Input of virgin materials per capita	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Water used for production processes	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Domestic Material Consumption (DMC)	• Reference Framework for Sustainable Cities (http://app.rfsc.eu/) and CIRCTER Indicators
		• Material consumption per capita	• CIRCTER Indicators
		• Use of the local natural endowment	• CIRCTER Indicators
		• Development of resource consumption over time	• CIRCTER Indicators
		• Use of renewable resources (percentage of imports - net and domestic - consisting of biomass compared to total imports	• Circle Economy - City Circle Scan for the city of Amsterdam
		• Share of green public procurement	• Reference Framework for Sustainable Cities (http://app.rfsc.eu/)
		• Green public procurement procedures and purchasing (strategies in place and awareness campaigns)	• Urban Ecosystem Europe
		• Circular Economy procurement	• London – Circular Economy indicators
	• Waste generation	• Total waste generated per capita	• CIRCTER Indicators
		• Different waste categories per capita	• CIRCTER Indicators
		• Waste intensity per NACE activity	• CIRCTER Indicators
		• Plastic uses prevention (including single-use)	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Number of water fountains (as a proxy for plastic waste prevention)	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Waste reduction policies	• European Green City Index
		• Volume of solid waste generated	• Indicators for Sustainability Barcelona Agenda 21 Indicators, Dublin Development Plan 2011-2017
		• Tonnes of (methane producing) organic waste diverted from landfill	• Indicators for Sustainability Barcelona Agenda 21 Indicators, Dublin Development Plan 2011-2017 (Dublin case study)
		• Diversion of landfill of biodegradable waste	• Reference Framework for Sustainable Cities (http://app.rfsc.eu/)
		• Annual amount of solid waste (domestic and commercial)	• Urban Audit Reference Guide / Environment - cities and greater cities [urb_cenv]
		• Annual amount of solid waste (domestic and commercial) processed by landfill sites	• Urban Audit Reference Guide / Environment - cities and greater cities [urb_cenv]
		• Annual amount of solid waste (domestic and commercial) processed by incinerators	• Urban Audit Reference Guide/ Environment - cities and greater cities [urb_cenv]
		• Annual amount of solid waste (domestic and commercial) given to other disposal units	• Urban Audit Reference Guide/ Environment - cities and greater cities [urb_cenv]

[31] The table presents the original list of CE indicators that was prepared as a result of the mapping exercise. As the study progressed, some of these indicators were re-categorised and refined, which is why in some cases there is a discrepancy between the indicators presented in Table 12 and Table 13.

		• Municipal waste generated (domestic and commercial), total - 1000 t [urb_cenv]	• Urban Audit Reference Guide/ Environment - cities and greater cities [urb_cenv]
		• Tonnes of waste disposed of per inhabitant and per year (building and demolition waste, industrial waste, domestic waste, retail and service waste)	• Urban Sustainability Indicators
		• Municipal waste, defined as household and similar waste collected by or on behalf of municipalities, and originated from household, offices and small businesses	• OECD (2017), Green Growth Indicators 2017, OECD Publishing, Paris
		• Municipal solid waste (t/cap/year)	• Eurocities - Key Performance Indicators for Sustainable Digital Multiservice Cities
		• Landfill rates of municipal waste, defined as the amounts of municipal waste disposed at landfills as a percentage of amounts treated	• OECD (2017), Green Growth Indicators 201, OECD Publishing, Paris
		• Landfill tax rates, the tax levied per tonne of municipal waste disposed in landfills	• OECD (2017), Green Growth Indicators 2017, OECD Publishing, Paris
		• Percentage of city population with regular solid waste collection (residential)	• Melbourne / ISO 37120
		• Total collected municipal solid waste per capita	• Melbourne / ISO 37120
		• Percentage of the city's solid waste that is disposed of in a sanitary landfill	• Melbourne / ISO 37120
		• Percentage of the city's solid waste that is disposed of in an incinerator	• Melbourne / ISO 37120
		• Percentage of the city's solid waste that is burned openly	• Melbourne / ISO 37120
		• Percentage of the city's solid waste that is disposed of in an open dump	• Melbourne / ISO 37120
		• Percentage of the city's solid waste that is disposed of by other means	• Melbourne / ISO 37120
		• Hazardous Waste Generation per capita (tonnes)	• Melbourne / ISO 37120
		• Percentage of the city's wastewater that has received no treatment	• Melbourne / ISO 37120
		• Waste Electrical & Electronic Equipment (WEEE) management	• Flanders - Inventory of Circular Economy indicators
		• All waste for all industry sectors (tonnes of waste)	• London – Circular Economy indicators
		• Management of local authority waste, share of waste to the following categories: landfill, incinerated, recycled, other	• London – Circular Economy indicators
		• Waste intensity per household (tonnes of waste per household)	• London – Circular Economy indicators
	• Food waste	• Initiatives/awareness campaigns at city level for food waste reduction	Various initiatives/projects
		• Edible (avoidable) food waste per year (tons/year)	
		• Energy recovery from residue stream	
	• Others	• Consumption-based GHG emissions (consumption of goods and services produced in the cities)	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Resource footprint indicator based on Cumulative Energy Extracted from the Natural Environment (CEENE)	• Flanders - Inventory of Circular Economy indicators
		• (Energy) Recoverability Benefit rate	• Flanders - Inventory of Circular Economy indicators
		• Share of environmentally related tax revenue, expressed as a percentage of total tax revenue and compared to GDP and to labour tax revenue	• OECD (2017), Green Growth Indicators 2017, OECD Publishing, Paris

		• CO_2 emissions	• Circle Economy - City Circle Scan for the city of Amsterdam
		• Energy consumption of public buildings per year (kWh/m²)	• Melbourne / ISO 37120
		• Circularity of household consumption (ratio of spending on services to spending on goods)	• London – Circular Economy indicators
		• Material intensity per unit of GVA (tonnes/per £million), sum of all materials	• London – Circular Economy indicators
		• The percentage of total energy derived from renewable sources, as a share of the city's total energy consumption	• Melbourne / ISO 37120
		• Scope 3 emissions (consumption-based methodology), $MtCO_2e$	• London – Circular Economy indicators
Theme 2: Waste management	· Overall recycling rates	• Recycling rate (Percentage diverted from waste stream)	• Indicators for Sustainability Barcelona Agenda 21 Indicators, Dublin Development Plan 2011-2017 / Flanders - Inventory of Circular Economy indicators
		• % of waste recycled	• Indicators for Sustainability Barcelona Agenda 21 Indicators, Dublin Development Plan 2011-2017 (Dublin case study)
		• Municipal waste processed according to differentiated refuse collection schemes (pay as you throw)	• Urban Ecosystem Europe
		• Recycling rate (% per tonnes, percentage of the city's solid waste that is recycled)	• Eurocities - Key Performance Indicators for Sustainable Digital Multiservice Cities
		• EOL-RIR (End of Life Recycling Input Rate)	• Flanders - Inventory of Circular Economy indicators
		• Recyclability benefit rate	• Flanders - Inventory of Circular Economy indicators
		• Indicators on separate collection	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Recycling or recovery rate of different waste streams	• CIRCTER Indicators
		• Breakdown of waste streams by different treatment options	• CIRCTER Indicators
		• Material recovery (includes recovery for recycling and composting)	• OECD (2017), Green Growth Indicators 2017, OECD Publishing, Paris
	• Recycling rates for specific waste streams	• Waste taken back by the industry for reuse/recycling	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Annual amount of solid waste (domestic and commercial) that is recycled	• Urban Audit Reference Guide/ Environment - cities and greater cities [urb_cenv]
		• Percentage of the city's solid waste that is recycled	• Melbourne / ISO 37120
		• Percentage of the city's hazardous waste that is recycled	• Melbourne / ISO 37120
	• Water management	• Percentage of city population served by wastewater collection	• Melbourne / ISO 37120
		• Percentage of the city's wastewater receiving primary treatment	• Melbourne / ISO 37120
		• Percentage of the city's wastewater receiving secondary treatment	• Melbourne / ISO 37120
		• Percentage of the city's wastewater receiving tertiary treatment	• Melbourne / ISO 37120
		• Grey and rain water use (% of houses, houses equipped to reuse grey and rain water)	• Eurocities - Key Performance Indicators for Sustainable Digital Multiservice Cities
		• Share of the urban waste water load (in population equivalents) treated according to the applicable standard -% [urb_cenv]	• Urban Audit Reference Guide/ Environment - cities and greater cities [urb_cenv]

Theme 3: Secondary raw materials	• Contribution of recycled materials to raw materials demand	• Reduction in imported secondary raw materials	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Share of secondary or recycled materials in the raw materials	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• "Reused" public buildings and spaces (sq.m)	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Mass of waste resources recovered and re-introduced in a production cycle as secondary raw material (kg/year)	• SCREEN project
		• Cyclical material use rate	• Flanders - Inventory of Circular Economy indicators
		• MSA – Material System Analysis	• Flanders - Inventory of Circular Economy indicators
	• Trade in recyclable raw materials	• Trade in recyclable raw materials within cities	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Trade in secondary raw materials	• Flanders - Inventory of Circular Economy indicators
Theme 4: Competitiveness and innovation	• Private investments, jobs and gross value added	• Number of organisations with environmental certification.	• Indicators for Sustainability Barcelona Agenda 21 Indicators, Dublin Development Plan 2011-2017 (Barcelona case study)
		• Number of organisations with registered environmental management systems according to EMAS and/or ISO 14001 or other recognised enviornmental certification schemes	• Reference Framework for Sustainable Cities (http://app.rfsc.eu/)
		• EMAS and ISO 14001 certification of public authorities	• Urban Ecosystem Europe
		• Number of environmental [CE] professionals	• China Urban Sustainability Index
		• Share of certified companies (% of companies).	• Eurocities - Key Performance Indicators for Sustainable Digital Multiservice Cities
		• Share of companies based in the city holding an ISO 14001 certificate	• Eurocities - Key Performance Indicators for Sustainable Digital Multiservice Cities
		• Public energy technology RD&D expenditures directed at “renewable energy” and “fossil fuel energy”, expressed as percentages of total public energy RD&D	• OECD (2017), Green Growth Indicators 2017, OECD Publishing, Paris
		• Private investment, jobs and GVA: recycling sector, repair and reuse sector	• Flanders - Inventory of Circular Economy indicators
		• Number of enterprises receiving financial support in connection with the CE	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Amount of financial aid granted to companies in connection with the CE	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Number of economic operators supported/trained in CE	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Number of Circular services	• Circle Economy - City Circle Scan for the city of Amsterdam
		• Direct jobs in CE (identify by 5-digit SIC-code)	• London – Circular Economy indicators
		• Indirect jobs in the CE (jobs dependent on CE, I/O method)	• London – Circular Economy indicators
		• Share of city’s GVA from CE activity	• London – Circular Economy indicators
		• Number of business supported	• London – Circular Economy indicators
		• Employment and value added in selected environmental protection activities expressed as a percentage of total; sewerage, waste management and remediation	• OECD (2017), Green Growth Indicators 2017, OECD Publishing, Paris
	• Patent	• Actually applied patents fro CE at the city level	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)

		• Technology development: the number of inventions (simple patent families) developed by a country's inventors, independent of the jurisdictions where a patent application has been registered (*i.e.* all known patent families worldwide are considered)	• OECD (2017), Green Growth Indicators 2017, OECD Publishing, Paris
		• Number of new patents per 100 000 population per year	• Melbourne / ISO 37120
Process indicators	Not included in the EC monitoring framework for the Circular Economy	• Awareness raising campaigns for motivating stakeholders to take up CE measures	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Number of seminars organized on the CE under the PREC	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Number of pilot projects on the CE (*e.g.* on involving retailers)	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Citizens involvement	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Number of demonstration projects	• London – Circular Economy indicators
		• Number of CE courses PhDs/university courses, patent	• London – Circular Economy indicators
		• Number of schools that participate in environmental education projects	• Indicators for Sustainability Barcelona Agenda 21 Indicators, Dublin Development Plan 2011-2017 (Barcelona case study)
		• Level of implementation of Agenda 21 processes	• Urban Ecosystem Europe
		• Environmental education (% per school)	• Eurocities - Key Performance Indicators for Sustainable Digital Multiservice Cities
		• Number of legislative and normative barriers identified and resolved	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Number of legislative and normative incentives created	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Number of people trained in CE trades	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Number of students trained in CE occupations	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Number of pilot cases set up via calls for projects / living lab	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Number of economic operators sensitized on CE	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Budget amount allocated to calls for projects / living lab made / implemented and number companies having benefited.	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Budget amount and number of pilot public markets in CE developed in the city/province	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
		• Number of new neighbourhoods incorporating the principles of the CE	• Bruxelles - Programme régional en économie circulaire 2016 – 2020 (2016)
Industrial symbiosis	Thematic area not included in the EC monitoring framework for the Circular Economy	• Number of companies involved in industrial symbiosis	Various projects
		• Investment in symbiosis	
		• Number of Eco-industrial parks	
		• Cubic metres of water saved	
		• Collective annual savings across firms	
		• Tons per year in CO_2 savings	
		• Million tonnes of landfill diversion	
		• Million tonnes of materials recovered and reused	
		• Billion in cost-savings	

		• Tonnes of virgin resources saved	
		• Tonnes of waste turned resources	
Eco-design	Thematic area not included in the EC monitoring framework for the Circular Economy	• Activities performed by cities that encourage the implementation of eco-design measures (*e.g.* promoting extended product lifetime, ability to re-use components or recycle materials from products at end-of-life, use of re-used components and/or recycled materials in products)	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
Collaborative economy (Main source: Single market scoreboard)	Thematic area not included in the EC monitoring framework for the Circular Economy	• Use of Composite indicator representing the combined scores of the business and regulatory environment surrounding the collaborative economy	• "Collaborative Economy - Single Market Scoreboard - European Commission". 2018.
		• Use of individual thematic indicators (on regulatory environment): accommodation, transport, finance, public administration and business support	• "Collaborative Economy - Single Market Scoreboard - European Commission". 2018.
		• Qualitative indicators on single use plastics	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Actions by the city intended to encourage the procurement of articles that use secondary raw materials	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Availability of a roadmap for resource management	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Availability of innovative schemes for businesses at the city level, which are related to CE	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Awards for circular businesses (*e.g.* stamps, stickers)	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
		• Cross-learning and exchanges between cities	• Indicators for a Circular Economy Transition in Cities – Workshop (12 September 2018)
Additional indicators suggested by stakeholders as a part of the consultation process under the study		• Number of package free shops	
		• Number of supermarkets and restaurants partnering in a ´left-over give away-network´	
		• Does the city have a Circularity Officer, with staff and budget?	
		• Recruitment and reward plan for acquisition of circular companies by the city	
		• City preference for eco/modulation in procurement and subsidies	
		• Litter in public space pers citizen in kilo	
		• Illegal dumping in public space per citizen per kilo	
		• M2 reserved for eco/activity/CE in spatial plans or in agreement with commercial estate developer (CE activity is considered collecting, managing and production of materials)	