Journal of Cleaner Production 305 (2021) 127058

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Towards a circular economy in cities: Exploring local modes of governance in the transition towards a circular economy in construction and textile recycling

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A R T I C L E I N F O

Article history:
Received 14 January 2020
Received in revised form
24 February 2021
Accepted 6 April 2021
Available online 22 April 2021

Handling editor: Cecilia Maria Villas Bôas de Almeida

Keywords:
Circular economy
Waste
Recycling
Governance
Textile
Demolition

A B S T R A C T

Designing circular economy policies and planning approaches in cities is an emerging research field and the aim of the present paper is to contribute to the existing body of literature by analysing multiple governance forms whereby municipalities can support and facilitate a local level transition to a circular economy. The purpose of this article is therefore to analyse how cities and municipalities can support and facilitate the circular economy through multiple modes of governance, e.g. through the use of own assets to support the circular economy; the use of the ownership of utilities and waste companies to support the circular economy; the use of rule enforcement and/or economic regulation or through facilitating, coordinating, collaborating and encouraging. The analysis in the article is based on two in-depth case studies of projects seeking circular economies, in which Danish municipalities collaborated with local stakeholders to close the material loop for demolition materials and textile waste. Overall, this study is based on an action research approach that emphasises the benefits of co-innovation processes carried out between multiple stakeholders. The analysis of the case studies concluded that municipalities can function as an important change agent to support and facilitate a transformation towards a circular economy.

1. Introduction

Increasing pressure on resources and concerns about environmental impacts and climate change (Steffen et al., 2015; UNEP, 2019) are prompting companies and governments to search for strategies to deliver sustainable development. The circular economy is regarded as a promising concept for policymakers (European Commission, 2015) and businesses (WBCSD, 2017) to close the material loops in consumption and production systems. Over the last decade, the circular economy concept has attracted increasing attention as a framework to understand and guide businesses and policymakers (Bocken et al., 2016; Ghisellini et al., 2016; Korhonen et al., 2018). However, the central idea about material cycles and resource limitations has existed since the beginning of industrialisation (Desrochers, 2002). The origin of the CE concept can be traced back to theoretical contributions from Boulding (1966) on the spaceship economy to later contributions from the limits to growth report in the 1970s (Meadows, 1972), and to the industrial ecology (Erkman, 1997; Frosch and Gallopoulos, 1989) and the cradle-to-cradle (Braungart et al., 2007) literature. Also, the urban perspective on closed-loop systems, as illustrated by the urban metabolism concept, helped inform the creation of the development of the CE concept (Bolger and Doyon, 2019). The role of cities and urban systems has therefore been a central part of the CE concept since its early days.

2. Circular economies in cities

There exist a wide variety of definitions of the circular economy. Blomsma and Brennan (2017) characterised the circular economy concept as an "umbrella concept" that is used as a broad heuristic to develop strategies and policies at different scales, from global production and consumption systems to cities and municipalities. Kirchherr et al. (2017) identified no less than 114 different definitions of the circular economy and also found that circular economy definitions most often relate to the 4R framework (reduce, reuse, recycling and recover). This CE framework has strong connotations to the waste hierarchy, which is used as a steering principle to rank most desirable waste policies in the EU Waste Framework Directive

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https://doi.org/10.1016/j.jclepro.2021.127058
0959-6526/

(2008/98/EC). Since all EU member states must adhere to the Waste Framework Directive, it is unsurprising that the circular economy activities in Europe have a strong bias towards this definition of the circular economy.

At its core, the circular economy concept has two main interlinked aspects, namely the circular *flows of physical materials* (the material aspect) and the *economy of these flows* (the economic aspect). The material aspect has to do with the creation of closed-loop flows. This involves flows of raw materials, intermediate products, final products (plus the services they provide), the use of the products and the management of the products as waste (in the linear system or semi-closed-loop systems) or as raw materials for the production of new products in the circular economy. The material aspect also involves the energy use associated with these flows and the environmental issues that the flows may cause as the materials run through the economy. The Ellen MacArthur Foundation (EMF, 2012) and McDonough et al. (2007); Braungart et al. (2007) divide material flows into two main types: technical and biological flows. The EMF "butterfly" model, which can help illustrate biological and technical material flows, has become widely used by policymakers and academia. The butterfly model tends to focus on the waste flows of end-of-life products and their pathways back into the production system (by reuse or recycling). However, the model pays less attention to how by-products and waste are interchanged between companies in the production system. Such a perspective is provided by the industrial ecology literature, which emphasises the processes by which materials from one company can be used as raw material by another company (Clift and Druckman, 2015).

The economic aspect of the circular economy has to do with the economic costs and revenues generated as materials flow through the economy, the business models that are deployed (Bocken et al., 2016), and the regulation and legislation that constitute the economic framework conditions for the businesses. Several studies have indicated that the transition to a circular economy opens up opportunities for the development and adoption of new ways of generating revenue and with this, new business models (Bocken et al., 2016; WBCSD, 2017).

Very often circular economy systems are characterised by a complex relationship between the private sector and the public sector, where the public sector not only provides the framework conditions but also takes an active role in creating partnerships and support systems to facilitate the transition to a circular economy.

2.1. The role of cities in the circular economy

With around half the world's population living in urban areas, cities are a main contributor to environmental problems, resource consumption, energy use and GHG emissions (UNEP, 2019; Wang et al., 2018). While on the one hand cities often have higher per capita consumption, cities on the other hand also often exhibit higher resource efficiency per unit of income and thereby provide a great potential for efficiency (UNEP, 2019). The UN Global Environment Outlook 2019 forecast increasing future urbanisation and argues that this development if managed poorly would be associated with high risks, but also that the urbanisation trend has a potential to contribute positively to helping solve environmental problems and to reducing resource consumption if local governments can manage to develop and implement technologies, that due to economies of scale, would be unfeasible in rural and less densely populated environments (UNEP, 2019).

Many cities are today strongly involved in circular economy activities. Bernhardt et al. (2018) identified 40 examples of city-level circular economies in diverse cities across the globe, covering topics such as city-wide circular strategies, urban refurbishment, public procurement, utilities and municipal waste. A number of pioneering cities, such as Amsterdam and Glasgow, have used material flow analysis methods to identify their main resource flows and to target projects and policies accordingly.

There are several reasons why cities and local governments can play an important role in the transition to a circular economy. *First*, most cities and local governments are responsible for (or at least heavily involved with) the management of waste. They are thereby positioned at the end of the linear material flows, and are responsible for managing the massive amounts of waste that are produced in the economy, and therefore they have a natural interest in the fate of these flows. In most countries, local governments also must meet recycling targets and they are therefore naturally involved in circular economy activities. The task of handling waste flows in cities has increased over time and is expected to increase further, both in volume and importance, with the growth in urban populations across the globe. The UN estimates that two-thirds of the global population will live in cities by 2050 (UNDESA, 2018), putting a massive strain on local governments to handle and recycle material flows. *Second*, circular economy activities overlap with many other policy objectives that cities typically also have to deal with, e.g. energy, water, transport and air pollution. For instance, waste management has strong linkages to climate change mitigation as many waste flows are treated in waste incineration plants (municipal solid waste) or biogas plants (organic waste from industries and households). Circular economy activities also impinge on sustainability plans, such as Local Agenda 21 plans or SDG city plans. The economic aspect of the circular economy also has an influence on many economic policies at the city level, such as employment policies, business support and entrepreneurship policies. *Third*, cities and local governments often act as a strong bridge between citizens and private sector organisations. Cities and local governments often act as facilitators that can enable collaboration between stakeholders from the private sector, knowledge institutions and citizens. The degrees to which municipalities engage in such activities differ from country to country and even between municipalities within the same country. In countries such as the Netherlands and in the Nordic countries (Finland, Sweden and Denmark), there is a well-established tradition of municipalities engaging with companies, knowledge institutions and citizens and acting as a facilitator to bring parties together and to drive action (Christiansen et al., 2019).

2.2. Local governance of the circular economy

The research on circular cities often focuses on developing indicator systems to assess, monitor, evaluate and compare circular economy initiatives at the city level. Gravagnuolo et al. (2019) analysed the CEs among a group of selected port cities to evaluate their criteria and indicators for achieving a CE. Wang et al. (2018) studied CEs among Chinese cities and developed an indicator system to evaluate and monitor the CE progress at a city level. Marin and De Meulder (2018)Marin and De Meulder (2018) studied urban circularity in four selected city initiatives with an emphasis on the spatial design dimension of urban circularity. Petit-Boix and Leipold (2018) reviewed circular economy activities in cities across the globe and found a wide geographical representation of cities engaged with circular economy activities across the globe, with particular concentrations clustered in Europe and China. The circular economy activities identified by Petit-Boix and Leipold (2018) covered a broad range of strategies, but primarily targeting infrastructure, industry, consumption and urban planning. Obersteg et al. (2019) analysed the CE, using a PESTEL-O method, in a comparative study of six European cities with public sector involvement in CE initiatives and found a lack of policy

coordination between the levels of government, a lack of horizontal coordination between cities and a lack of public sector coordination and support for private CE initiatives.

The current CE literature on cities and municipalities can be divided into two primary lines of research. The first line of literature focuses on developing indicator systems to monitor and evaluate the CE at a city level (Avdiushchenko and Zajaç, 2019). The second line of literature aims to compare and identify the similarities and differences between projects, sectors and initiatives that are the targets of cities in CE-related activities (Bolger and Doyon, 2019; Gravagnuolo et al., 2019; Obersteg et al., 2019). However, less attention is given in the literature to exploring how cities and municipalities collaborate with stakeholders to accelerate the development of a CE and further research on municipal and city-level governance is required to accelerate the transformation to a circular economy. Consequently, this article aims to contribute to closing this knowledge gap.

Cities and local governments can play an important role as change agents to create sustainable cities (Bulkeley and Betsill, 2005). Bolger and Doyon (2019) conducted a comparative study of the cities of Malmö and Melbourne to analyse how municipal planning could support the transition to a CE and found that strategic urban planning could function as a vehicle for the transformation of CE objectives into specific actions. In attempting to understand how the role of a strategic planner and change agent unfolds, scholars have moved from focussing on hierarchical, top−down-oriented command-and-control regulation, often labelled “government”, to a perspective focussing on non-hierarchical modes of coordination and decision-making, termed “governance” (Bulkeley and Kern, 2006; Corfee-Morlot et al., 2009; Zvolska et al., 2019). Bulkeley and Kern (2006) studied the role of municipalities in climate change mitigation policies and developed a typology for local governments, whereby actions could be divided into four main modes of governance as described below. This typology based on the four roles can be applied to other areas of municipal planning as well, although the specific character of the four modes of governance may differ. In a study of the sharing economies in four Swedish cities, Palm et al. (2019) extended the typology by adding “governing by partnership”; however, this could also be characterised as a sub-form of “governing by enabling”. Cavicchi et al. (2017) used the same framework to analyse sustainability and bioenergy development in Emilia Romagna, Italy. Based on Bulkeley and Kern (2006), this paper applies the following typology for the modes of governance:

1) *Self-governance*, defined as the capacity of a municipality to govern its own assets and activities. This mode of governance is often described as governing the municipality as a company, focussing on activities that take place within the legal boundaries of the municipal organisation.
2) *Governing by provision*, defined as governance through the provision of services and resources. This mode of governance often involves governance through municipality-owned agencies and companies in, for example, wastewater, utilities, heating companies, transport companies and waste companies.
3) *Governing by authority*, defined as governance using authority, such as regulation. This mode of governance involves governing through rules and enforcement, including direct and economic regulation (rules, taxes, tariffs, etc.), but also through planning activities that are legally binding on companies and citizens.
4) *Governing through enabling,* defined as governance through facilitating, coordination, collaboration and encouraging. This mode of governance can take many diverse forms, spanning from formal partnerships to informal community engagement.

The distribution of authority between the levels of governance varies from country to country, and the potential for municipalities to engage in, for example, legally binding planning activities or to govern by authority may be quite different. Scandinavian countries have a tradition of a deep distribution of power to local governments.

The purpose of the present paper is to explore how cities and municipalities can combine multiple modes of governance to support and facilitate a local level transition from a linear economy towards a circular economy, in which physical flows are looped back into the production of new products and services. The analysis in this paper is based on two in-depth case studies of Danish municipalities working in collaboration with local stakeholders to close the material loops of two targeted waste streams. The first case study explores the recycling of textile waste, while the second case study explores a circular economy in the construction and demolition field. The case studies are discussed in detail, followed by a discussion about how municipalities can support and facilitate the transition to a circular economy using different modes of governance.

2.3. Local governments in Denmark

A report from the Nordic Ministers Council (Christiansen et al., 2019) focussing on circular economies in municipalities in the Nordic countries identified a broad variety of projects and activities targeting the circular economy, stretching from small-scale projects with a few partners to large-scale inter-municipal projects.

Like most Scandinavian countries, the political system in Denmark distributes relatively large autonomy to local governments (municipalities) compared to the political systems in many other countries. Denmark is divided into 5 regions and 98 municipalities. The regions’ main obligation is to manage healthcare (hospitals and psychiatry services), whereas the municipalities have a broad spectrum of responsibilities. This also implies that the central government and the municipalities are the most important government levels for promoting circular economy activities. In Denmark, the municipalities are the primary level of government involved in waste management, with the overall responsibility for all household waste. The municipalities must adopt waste plans that cover four years and point 10 years into the future. Additionally, Danish municipalities usually hold joint ownership of waste management companies, which operate the recycling stations in Denmark as well as the 19 Danish combined heat and power waste incineration plants. This ownership relation provides an often-used opportunity for governing by provision.

3. Methods

This article presents the results from a multi-stakeholder, co-innovation project called “Partnership for Circular Municipalities” that was undertaken in the Capital Region of Denmark. The purpose of the partnership was to support, demonstrate and develop the role of local governments (municipalities) in promoting the transition to a circular economy through partnerships between municipalities, waste companies and knowledge institutions.

The project was financed by Regional Council Development Funds. The consortium comprised five municipalities (Bornholm, Copenhagen, Albertslund, Rudersdal and Hørsholm), three waste companies (BOFA, Vestforbrænding and Norfors), and three knowledge institutions (Roskilde University, the think tank CONCITO and Gate21).

Four demonstration projects were carried out as part of the project:

1) Recycling construction and demolition waste
2) Promotion of a circular value chain in the textiles industry, with a combined focus on the recycling/upcycling of textile waste and the green public procurement of reused textiles
3) Direct recycling and upcycling of waste fractions 4) Circular business development, focussing on resource efficiency.

To increase the competences and knowledge of the circular economy among staff in the municipalities, three masterclasses were conducted in the project, focussing on the circular economy in municipalities, circular public procurement and circular organisations.

Finally, the project intended to anchor the circular economy concept strategically and politically in the participating organisations. This was accomplished through a series of meetings with decision-makers in the participating municipalities, through the establishment of an advisory board consisting of decision-makers in local municipalities and through the development of a communication strategy for the project.

This article presents the results of two of the demonstration cases that were conducted in the project, namely the textile case study and the construction and demolition case study (Table 1). This article analyses these case studies to show how local governments can combine multiple modes of governance to facilitate a transition towards a circular economy.

The two cases were chosen for analysis in this article for several reasons: both cases involved multiple stakeholders, both cases involved co-innovation processes in which multiple stakeholders collaborated towards a common goal and both cases illustrated multiple modes of local governance (Bulkeley and Kern, 2006).

The case studies address the two key aspects of the circular economy concept: the material aspect and the economic aspect. In the first case, the material aspect relates to the physical flows of textiles in the Danish waste system and potential scenarios for future flows. The economic aspect relates to the costs of these flows. In the second case, the material aspect relates to the physical flows of demolition materials generated from demolished buildings on the Danish island of Bornholm, while the economic aspect relates to the potential costs and economics related to the recirculation of these materials.

Using an in-depth case-study approach, the two cases explored how municipalities can contribute to closing the local materials loop and contribute contextualised knowledge about the barriers and potential for the development of a circular economy in these fields. Following Gibbons et al. (1994), the case studies were conducted as a modus 2 type of research, whereby the researcher and the local stakeholders collaborate in the production of knowledge. Modus 2 research can also be seen as a type of action research, which is a research approach that has been used by several researchers for the study of sustainability governance (Cramer, 2020; Wittmayer et al., 2014). The modus 2 approach allowed following an alternative to the classical research approach, whereby the researcher could remain an independent observer who collects data to answer research questions derived from academia itself. Modus 2 action research involves a collaborative effort in defining research questions and is based on a multi-stakeholder approach and co-innovation processes. Wittmayer at al (Wittmayer et al., 2014). define action research as: "*the collaborative production of scientifically and socially relevant knowledge, transformative action and new social relations, through a participatory process addressing a particular question formed in the interaction between researchers and other actors*", thus emphasizing the participatory elements of knowledge production in a joint project with non-academic partners.

This research approach implies that the author was actively involved in the initial stages of formulating the aims and targets for the overall project as well as for the individual cases in collaboration with the local stakeholders, and in the collection and interpretation of data as well as being responsible for the final evaluation of the project as a whole. Additionally, the overall aim of the present project was two-fold: on the one hand, to generate scientific knowledge about local governance for transitioning to a circular economy and on the other hand, to support a real transition through testing and demonstrating the process. The author was additionally involved in the design and implementation of master classes and the establishment of an Advisory Board for Circular Economy in Local Governments, with both initiatives established as a part of a larger project (but not presented in this article).

3.1. The textile case methodology

The textile case was carried out as a collaboration between Rødovre Municipality, the largest Danish waste company Vestforbrændingen, Roskilde University and a private consultant (Affaldskontoret). The project was divided into 2 steps: First, a collection scheme was established to map and assess the quantity and quality of waste textiles. The collection scheme was implemented by Rødovre Municipality for used clothing and shoes. Two different collection systems were tested, one for one-family homes and another for terrace homes and high-rise homes. Textile waste was collected at the doorstep from 530 one-family homes and additionally 8 containers were placed at established collection facilities servicing 356 high-rise homes and 552 terrace homes. Information folders were produced and distributed to citizens. The two different collection systems were chosen since the socio-economic characteristics typically differ between high-rise homes and one-family homes. Typically, collection rates for source-separated municipal solid waste are higher in one-family homes than in high-rise homes.

Second, a scenario analysis was conducted by Roskilde

Table 1
Details of the two case studies.

	Textile case	Construction case
Objective(s)	To identify the potentials for the collection and recycling of textile waste and to explore how a future textile reuse/recycling system could be established	The case aimed to close the loop for the flow of construction materials in the Danish island of Bornholm and to bridge the gap between the generation of demolition waste and the construction of new buildings
Involved stakeholders	Rødovre Muncipality, Vestforbrændingen (waste company), Roskilde University and a private consultant	Bornholm municipality, Roskilde University, BOFA (waste company) and two private consultants
Main activities	1) Testing a collection scheme for textile waste 2) Scenario analysis	1) Testing pre-demolition audits and selective demolition to generate data about recycling opportunities and to establish a material bank 2) Assessment of the potentials for recycling construction materials 3) Establishing a recycling network for demolition waste

University to assess the current national flow of waste textiles and to explore future scenarios for the recycling of waste textiles. The scenarios were based on a material flow analysis method (Brunner and Rechberger, 2016), where the flows of textiles in Denmark were assessed and illustrated by Sankey diagrams. Data for the scenarios were obtained primarily from the Danish Ministry of Environment and an assessment of the potential recycling and reuse technologies (mechanical and chemical textile recycling techniques).

Two scenarios for 2025 were generated to quantify the total national opportunities for the recycling of waste textiles in Denmark. This 2025 date was chosen as the target year since the EU Waste Framework Directive requires the separate collection of textiles from 2025. The first scenario assumed continued increasing textile consumption, but with the existing NGO-based collection system in parallel with a collection system operated by the municipally owned waste companies. Based on the results from a collection test in Rødovre, a higher collection ratio (increasing from 3% to 16% in the municipal system) was also assumed. It was further assumed that it would be economically feasible to chemically recycle the poorest quality (2nd grade and lower) collected textiles.

A sorting test at a private textile collector was carried out during the development of the scenarios to test and validate the existing data on the fibre types and the quality of the collected textile waste textiles (100 kg of waste textiles) (Table 2). Since this quality assessment proved the waste complied with the quality characteristics provided in the national government data, no larger quality assessment was considered necessary. The test results were then used to calibrate the assumptions regarding the potential for chemical and mechanical recycling.

3.2. The construction case methodology

The construction case was carried out as a collaboration between Roskilde University, Bornholm Municipality, the waste company BOFA and two private consultants. The case aimed to close the loop for the flow of construction materials on the Danish island of Bornholm and to bridge the gap between the production of demolition waste and the construction of new buildings. To do so, three main tasks were carried out: 1) a test was made involving pre-demolition audits and selective demolition, whereby three selected buildings were demolished to generate data about recycling opportunities and to establish a material bank; 2) an assessment was carried out of the potential for the recycling of the construction materials. This assessment was based on a series of interviews with local stakeholders in the construction sector. The interviews were carried out as semi-structured interviews, and the results were analysed and documented in a separate background report. The results from the qualitative study were afterwards combined with quantitative, statistical data on the construction activities on the island, which was likewise compiled in another background report; 3) a green construction network was constructed. The network was established through a series of workshops with local companies in the construction sector. This part of the project aimed to convey knowledge from tasks 1 and 2 and to explore the potentials and barriers to transitioning towards a circular construction sector.

4. Case study 1: recycling waste textiles

Textiles are a product category associated with high environmental impacts throughout the value chain (Sandin and Peters, 2018). The production of natural fibres often involves a large consumption of energy, fertilizers, water and pesticides. During the processing of fibres and textiles (natural or synthetic), the use of energy, water and chemicals causes further environmental impacts (S;ajn, 2019). The expected increase in textile consumption in the coming years will likely contribute to further environmental problems (EMF, 2017). Textiles are therefore one of the most important flows that cities and local governments across the globe need to address in order to create a circular economy. Sandin and Peters (Sandin and Peters, 2018) distinguish between open-loop recycling and closed-loop recycling, where closed-loop recycling refers to recycling systems where fabrics or fibres are used again to produce new textiles and open-loop recycling systems refer to systems where fabrics or textiles are used to produce other products (insulation, plastic bottles, heat, electricity, etc.).

4.1. The textiles flow in Denmark

The recycling of textiles is an area that is attracting increasing attention and so textiles were chosen as a target material flow to assess in this project. The upcoming municipal waste plans in Denmark for the period 2019–2030 are expected to focus on increasing textile recycling and at the same time improving the quality of the recycling processes to enable compliance with EU requirements for the separate collection of textiles by 2025 (EC Directive, 2018/851) In this project, the potential for the collection and recycling of waste textiles was explored in a collaboration between Rødovre Municipality, the largest Danish waste company Vestforbrændingen, and Roskilde University. The reuse of second-hand textiles in Denmark (as in many other countries) is primarily organised by NGOs that collect, sort and export second-hand textiles to third-world countries. At the same time, some used textiles are shared between friends and family members and a smaller fraction is sold in digital marketplaces (Watson et al., 2014). Approximately 40% of household waste textiles are incinerated together with mixed municipal solid waste. Fig. 1 illustrates the flow of textiles in Denmark in 2016. Here, used textiles follow four main routes. The largest percentage is incinerated in Denmark (42,130 t), while part of the textiles is reused nationally, a large fraction (15,400 t) is collected by NGOs and exported to third-world countries, typically following transit in Eastern European countries, where the textiles are sorted, and a smaller fraction is mechanically recycled in Denmark in an open loop, mainly for non-clothing products, such as cloths.

Several reports show that there are a number of commercial reuse options for waste textiles in addition to being used as cloths and the like – partly where the fibres are recycled in new textiles and partly where the fibres/clothing are included in other products. In addition to pre-sorting, there is currently only limited sorting, processing and recycling capacities in Denmark. The lack of municipal experience with textile recycling and the fact that sorting and recycling generally take place abroad makes it difficult for the municipalities to assess the possibilities for a better utilisation of waste textiles.

4.2. The collection test

The first step in the project was to conduct a pilot collection scheme in Rødovre Municipality to assess the quantities and quality of household waste textiles. The findings from the collection test are presented in the Table 2 below.

Mechanical recycling makes it possible to recycle fibres from worn-out textiles, and future collection schemes under the revised waste plans post-2025 will need to collect these fractions as well. A general challenge for textile collection in Denmark is that Danish citizens are used to only handing in clothes that they consider as being in good shape (e.g. without holes or not worn out) because the current NGO-based collection system is set up for reuse in third-world countries. Citizens therefore need to change their

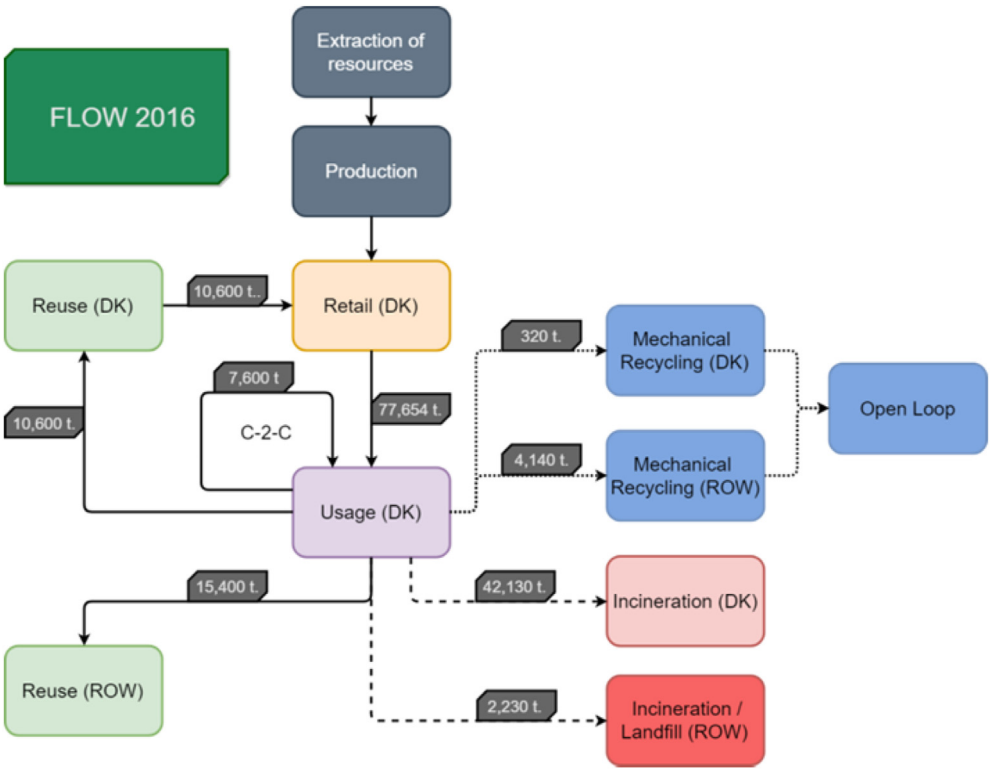

Fig. 1. Scenario A: 2016 Textile flow in Denmark (based on data from Danish Environmental Protection Agency 2018).

Table 2
Findings from the collection test (Rødovre Municipality/Affaldskontoret 2019).

	Collected in test (kg/household/yr)	Scaled up to the whole municipality (ton/yr)
Collected with bulky waste (530 households; 7800 if scaled up to the whole municipality)	1.3	10
Collected in containers from high-rise homes (900 homes in test; 10,500 if scaled up to the whole municipality)	6.5	70
Collected at recycling stations in municipality plus other organisations' containers		54
Assumed collected by NGOs and shops – based on a national average of 13 kg/household/yr		240

sorting practice and to be encouraged to hand in worn-out clothes along with clothes suitable for reuse. Based on the relatively low volumes collected in the test sorting scheme carried out in this project, it can be concluded that additional education and information is needed to make citizens change practice.

4.3. Scenarios for the future textile flow with increased recycling

To analyse the potential for the increased recycling of textiles in Denmark, a set of scenarios was developed based on a baseline projection and variations with increasing the amount of textiles recycled by mechanical and chemical processes.

The first scenario (Fig. 2) was based on the assumption that the current NGO-based system will be maintained, while a second scenario was developed to illustrate the potential of a new system whereby all textiles are collected under the municipal system and recycled in Denmark. This range was partly due to the uncertainty related to the actual fate of the exported textiles and partly to account for the uncertainties related to how these are end-of-life treated after reuse (landfilled, incinerated or recycled).

Scenario C (Fig. 3) can be understood as a more ambitious and challenging scenario that will require larger changes to be made to the existing system. Because Scenario C is based on a national system, it is easier for municipalities to verify that the collected textiles are actually recycled and that the system will create a closed loop where textile fibres are continuously recycled and not landfilled after being reused once, as is likely the case with the exported textiles today. The developed scenarios were discussed with the project partnership with representatives from the largest Danish waste company Vestforbrændingen, Rødovre Municipality and the two knowledge institutions Roskilde University and Gate21 in order to clarify the potential future policy options when implementing the EU Waste Framework Directive requirements for the separate collection of textiles by 2025. These discussions concluded that overall political decisions on the structure of the waste system need to be taken, especially with regards to the distribution of the roles and responsibilities between private collectors (NGOs) and the municipally owned waste companies. Additionally, Rødovre Municipality used the findings from the collection test to establish and implement a textile collection scheme covering the entire municipality as part of their waste management plan.

The data for the material flow analysis were quite rough and the scenarios were based on certain assumptions, which can naturally lead to significant uncertainties. The two most important

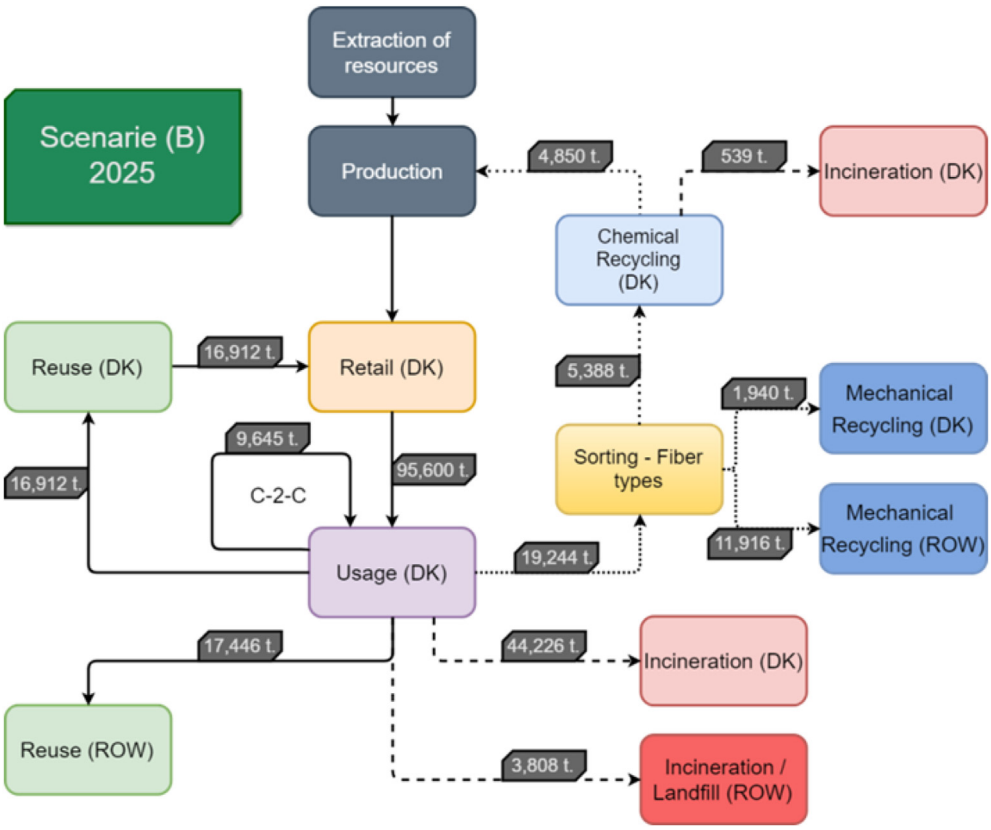

Fig. 2. Scenario B: 2025 Baseline textile flow in Denmark.

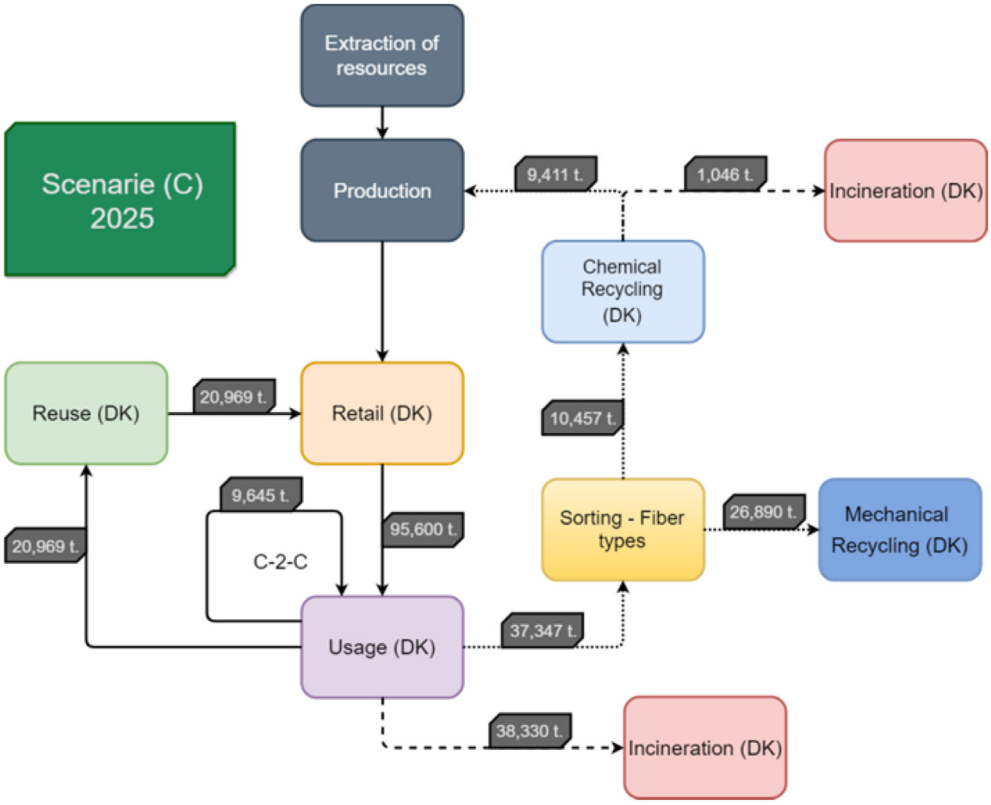

Fig. 3. Scenario C: 2025 Ambitious system with the national recycling of textiles.

uncertainties are related to 1) technological uncertainties about whether the chemical recycling of textiles will be commercially available at a large scale within the target time frame and 2) political uncertainties related to whether implementation of a national closed-loop system is realistic as this would require a significant change to the current system, and in scenario C, a showdown with the NGO-based collection system. Scenarios B and C were included to present and illustrate the potential in two ultimately different systems and to quantify the potential of a national closed-loop system. The scenarios were presented to decision-makers in the waste company; however, a final decision on the structure of the textile recycling system was still not taken.

The textile case illustrated two main modes of municipal governance, namely governance through provision and governance through authority. The first step in the project, in which Rødovre Municipality established a pilot collection scheme, illustrated governance through authority. Here, the collection scheme was legally binding, and citizens covered by the collection scheme were obliged to follow the instructions communicated and enforced by the municipality. The second part of the textile case, where Rødovre Municipality collaborated with Roskilde University and the publicly owned waste company Vestforbrændingen, can be regarded as a combination of governing by provision (as Rødovre Municipality was also a part owner of the waste company Vestforbrændingen) and governance through enabling.

5. Case study 2: recycling construction and demolition waste

Measured by volume, construction and demolition waste (CDW) is the most significant waste fraction in Europe, representing approximately one-third of all waste generated (European Commission, 2017), while in Denmark, CDW represents 37% of all waste produced. CDW covers a broad variety of materials, including concrete, bricks, plastics, metals, glass and gypsum. Despite the potential for the recycling of these materials being promising, in the EU only around half is recycled (European Commission, 2017). Furthermore, the recycling practices associated with CDW in Europe often result in a downcycling of the construction materials to a lower quality and functionality; whereby instead of being looped back into high quality use, such as the construction of new buildings, high-value construction materials are used as low-value road base and filling materials (Di Maria et al., 2018). As a consequence of this practice, economic value is destroyed and the potential for increased resource efficiency and avoided environmental impacts is underutilised (Ghisellini et al., 2016; Silva et al., 2017).

The island of Bornholm was determined to become a test island for the circular economy. The municipality had adopted an ambitious waste strategy called “Bornholm Showing the Way – Without Waste 2032” (BOFA, 2018), where it set out its aims to recycle all waste fractions by 2032 and to eliminate the need for waste incineration and landfill. The case study aimed to support this vision by exploring the possibilities for creating closed-loop value chains from the demolition to construction of new buildings in a public–private collaboration between the waste sector, the municipality (as the authority and as a construction client), the construction industry, knowledge institutions and citizens.

Closing the loop in the construction sector is a complex task that requires changes across a diverse group of stakeholders. Currently, the vast majority of construction materials generated from demolition is crushed and downcycled to lower value and functionality. Therefore, changes to demolition practices are needed, while at the same time practices among the companies involved in the construction of new buildings are needed to ensure the demand for recycled construction materials. Additionally, issues such as the quality (including environmental issues), durability and certification of materials need to be handled to allow the recycling of CDW.

5.1. Exploring selective demolition practices

Bornholm municipality manages a demolition fund that financially supports the demolition of worn-out houses, mainly in rural areas of the island. Priority in the demolition fund is given to buildings that contain building materials and building components with a high conservation value. Using the demolition fund, this case-study developed and tested selective demolition practices, created a warehouse for demolished construction materials and created links to private stakeholders involved in the construction of new buildings and in the renovation of old buildings that potentially would be able to use the materials, whereby a circular value chain could be established. The municipality’s use of the demolition fund could be characterised as self-governance since the municipality uses its own assets as a way to influence the local construction sector.

The first building was demolished in October 2018 applying selective demolition techniques and two additional buildings were demolished in the summer/autumn of 2019. Environmental screening was performed prior to demolition to identify any hazardous substances in the materials, such as PCB, asbestos or heavy metals, followed by resource mapping. The environmental screening is mandatory according to Danish law for buildings larger than 10 m^2 or if the renovation generates more than 1 ton of demolished materials (Danish Executive Order on Waste 2019). The resource mapping comprised two categories: one category containing materials for reuse and one category for recycling where additional work is necessary before the materials can be reused.

Table 3 illustrates the results of the resource screening against the result of the selective demolition from the first demolition project. The selected demolition generated less material for reuse and recycling than anticipated in the resource screening. The wooden floors for example turned out to be in less good shape and therefore only 20 m^2 out of the 110 m^2 identified in the resource screening were taken out for recycling.

5.2. Defining value from demolished materials

A central issue found during the first resource screening and demolition was the difficulty associated with determining the value of materials. In the project, the value of the demolished materials was assessed by carrying out an internet search for the prices of similar materials. In all three cases, a positive business case was identified when assessing the potential sales value of the construction materials against the cost of conducting a selective demolition, logistics and storage of materials. However, assessing the value of materials turned out to be a complex challenge. First, the value of the construction materials was determined by the quality of the material and the amount of labour (costs) needed to separate the valuable material from the other materials in the demolition process in order to secure a satisfactory quantity of the demolished material. Second, a larger quantity makes it easier to attract potential buyers. The value of simple and standardised materials, such rafter, bricks, tiles and wooden floors, was easier to establish than for more complex products, such as doors and windows. Even a simple product, such as tiles, may require detailed knowledge to assess their value. The first house that was demolished in the project, for example, included a special type of locally produced tiles (called Hasle tiles) that are in high demand when historic fishermen’s houses are renovated. A correct value-assessment during the resource scanning therefore necessitates a detailed knowledge about the local market for construction materials. This

Table 3
Results from the first demolition: expected resources versus achieved.

Part	Material	Expected, resource mapping	Demolished, achieved amounts
Outside parts			
Rafter	Rafter (wood)	31 pieces	23 pieces
Cellar, outer wall	Nature stone, mortar	63 m^3	0 m^3
Facade wall	Red bricks	63 m^3	58 m^3
Outer stairs	Granite	7 pieces	7 pieces
Inside parts			
Beams	Painted wood beams	14 pieces	14 pieces
Partition	Claystone	125 m^3	7.6 m^3
	Mirrors on walls, painted wood	12 lbm	9 lbm
	Gerichter	2 pieces	2 pieces
Floors	Wooden floors	110 m^2	20 m^2
	Tiles	15 m^2	5 m^2
Doors, inside	Doors and frames	16 pieces	16 pieces
Other	Woodburning stove	1 piece	1 piece

Source: Bornholm Municipality

may also be the case for products such as windows and doors, where knowledge of the local construction sector is needed to assess the value.

5.3. Looping construction materials back into the construction of new buildings

A main task in the project was to bridge the gap between demolition and construction. The municipality took an active role in exploring several options. Initially, the demolished construction materials were handled and stored by the local waste company BOFA in a facility connected to the local recycling station while potential users/buyers were identified. The group of potential users/buyers included local construction markets, upcyclers, citizens, the municipality itself and professional companies in the construction sector. A private enterprise with a business model aimed at recycling used bricks was contacted by the municipality and established a branch office on the island. A partnership agreement between the municipality and the company was created to make sure that the bricks from the demolition demonstration projects would be treated and reused in the construction of new buildings. In these processes, the municipality took an active role in establishing contacts with companies that could potentially use the demolished materials and acted as a facilitator.

To make sure that knowledge about the project and resources were disseminated to local construction companies, a network initiative was started by the municipality. A mapping exercise was commenced by the municipality to provide an overview of the local construction and demolition sector. This activity resulted in two reports. Local companies in the construction sector were invited to participate in a series of workshops to increase knowledge sharing, build competences and to create a circular value chain from demolition to construction. The workshops were organised by the municipality and as a result, a local green construction network was established covering companies involved in demolition, construction companies, architects and public authorities.

5.4. The role of municipalities in the transition towards a circular economy

Bornholm Municipality played a crucial role in this case and was actively involved in all stages of the process. The fact that Bornholm is an island influenced the creation of the green construction network, as the group of potential stakeholders in the construction industry to a large extent was limited by the geographical boundaries of the island. This also implied that many of the local stakeholders knew each other personally.

The demolition case illustrated how the municipality could use different modes of governance to influence the transition from a linear to a circular economy. In practice, the municipality combined all four main governance modes: self-governance (using the demolition fund to support selective demolition), governing by provision (using the ownership to the local waste company BOFA as a storage facility for the demolished construction materials), governing by authority (using waste planning and the waste management authority during demolition procedures) and governing through enabling (creating networks and partnerships between local stakeholders in the construction and demolition sector). Throughout the entire project, the most important role of the municipality was that of an enabler and change agent who could contact stakeholders and facilitate increased communication between stakeholders.

6. Discussion: the role of cities and local governments in the transformation towards a circular economy

Recent research has indicated that cities and local governments can play an important role in the creation of closed-loop production and consumption systems (Bolger and Doyon, 2019; Petit-Boix and Leipold, 2018). In political science, the traditional state-centred research, which typically sees the national state as a single sovereign authority, has been contested by researchers arguing that a broader perspective on governance is needed to fully understand the complex functioning of the public sector and to understand the interaction between public authorities and stakeholders in the private sector (Ehnert et al., 2018). This movement has led to a change in perspective from “government” to “governance” and as part of this process highlighted the role of cities and local governments. The exact role of local governments may differ from country to country due to the varying relationships between central governments and local governments resulting in different degrees of financial interdependence, different administrative structures, etc (Bulkeley and Kern, 2006; Ehnert et al., 2018). Despite these national differences, there is a clear trend that cities and local governments are increasingly defining policies, taking action, creating demonstration projects and collaborating in partnerships with private companies, citizens and knowledge institutions to facilitate and support the transition towards a circular economy (Bernhardt et al., 2018; Petit-Boix and Leipold, 2018). The so-called governance perspective not only pays increasing attention to the role of local governments but also emphasises the changing understanding of the role of local governments, from traditional command-and-control regulation to non-hierarchical modes of coordination and decision-making (Zvolska et al., 2019).

6.1. Local governments' potential for closing material loops

The two case studies above indicate that the potential for closing the loops of specific urban material flows through planning targeted activities initiated by local governments and implemented in collaboration with local stakeholders. The textile project case study indicated that a focussed strategy aimed at increasing the domestic recycling of natural and synthetic fibres using a mix of chemical and mechanical treatment processes could contribute significantly to a continued and increased recycling of textile fibres. The implementation of such a strategy would increase recycling rates and ensure that exported textiles that today have an unknown and uncertain fate could be handled domestically, where recycling rates could be monitored and documented. This led to developing our ambitious scenario C, which could additionally support the implementation of the EU Waste Framework Directive, which specifically addresses the recycling of textile waste. However, the developed scenarios also highlighted the need for clarifying the roles and responsibilities of all parties, especially with regard to the question of efficiency in having two parallel collection systems, one operated by the publicly owned waste companies focussed on recycling and one operated by NGOs focussed on the export of reusable textiles to third-world countries. Further research is needed in this area.

The demolition case study indicated the potential for an increased recycling of construction and demolition waste. The demonstration case illustrated that applying new procedures for environmental screening, resource mapping and selective demolition could increase the value of the produced demolition materials and generate demolition waste that potentially can be sent back in the chain to be used in the construction of new buildings at a higher level in the waste hierarchy. The demonstration project indicated that demolition materials that would otherwise have been crushed and used as filling materials can be recycled, provided that the procedures for resource mapping and selective demolition are followed and that the stakeholders involved possess the relevant knowledge, competencies and expertise to carry out such procedures and are able to accurately assess the value of the demolished construction materials. A lesson learned from the project is that increasing the knowledge capacity of local demolition companies is important to ensure selective demolition and reuse can be identified. Traditional demolition practices follow a simple model and the people involved typically only possess limited knowledge about the value of the construction materials and therefore have limited capabilities to conduct a reliable assessment of the potential value of the construction materials.

6.2. The role of local governments in a circular economy

The two case studies also illustrate multiple ways in which cities and local governments can act as change agents on their own as well as through interaction with external stakeholders in order to support the transition to a circular economy, thereby adding to the existing research on the role of local governments in the transition towards a circular economy (Bolger and Doyon, 2019; Gravagnuolo et al., 2019). Whereas existing research on the role of local government in the circular economy point towards the role of strategic urban planning (Bolger and Doyon, 2019), the analysis in this article suggests that municipalities can use several different modes of governance to act as change agents. The analysis illustrates that the involved municipalities during the case studies switched back and forth between four main modes of governance, as described in Table 4 below, depending on the situation and context. While Obersteg et al. (2019) analysed CE initiatives in six European urban areas and found a general lack of public sector support for private initiatives, the conclusions form this article point in the opposite direction and seem more in line with studies from Swedish and Dutch cities (Bolger and Doyon, 2019; Prendeville et al., 2018).

Local governments are in many countries heavily involved in planning and regulatory activities that overlap and affect the circular economy. Most importantly, local governments in many countries are responsible (or partly responsible) for handling waste. In Denmark, as in most of the neighbouring Scandinavian countries, this responsibility includes the development and implementation of policies, strategies and plans for the recycling, recovery and landfilling of material flows. This gives the local governments a natural stake in as well as potential influence on closing the loop of urban material flows.

Table 4 illustrates how the municipalities in the two case studies used a combination of multiple modes of governance to increase the recirculation of textile waste and CDW. The two cases demonstrate the potential for closing urban material loops, thus contributing to the development of the circular economy through governance through enabling – specifically in a partnership between local governments, businesses and knowledge institutions. Such partnerships can be organised in multiple ways. The results from the project suggest that local governments can act as an important anchor for such initiatives using diverse modes of governance. Choosing the right mode or modes of governance is partly a choice made locally and partly a choice set by national legislation. Governing by authority is primarily decided by the national level of governance, whereas the three other modes of governance to a much larger extent depend on the design of the local level policy goals, resource allocation and ambitions.

6.3. Limitations and generalisation

The implementation of circular economy policies varies significantly across the globe. McDowall et al. (2017) compared CE policies between Europe and China and found the Chinese CE policies primarily relied on a broad, top–down-based approach, whereas European policies tended to be based on a bottom–up approach with a more narrow scope focussing on environmental issues but with an emphasis on waste and recycling. The analysis in this article supports this conclusion. When specifically addressing local governments, the differences between regions in the world and countries become even larger as the level of autonomy at the local level of government varies significantly between different countries. A low degree of autonomy at the local level of government will limit the possibilities of local governments to influence the transition towards a circular economy. Issues such as local capabilities, knowledge, power and political will additionally influence local governments possibilities for acting as a change agent (Bulkeley and Betsill, 2005).

The distribution of responsibility between different layers of government is in Denmark to a large extent like in other Scandinavian countries, where planning responsibilities and local autonomy are distributed to local governments (municipalities). In other European countries, especially in the southern and eastern parts of Europe, less local autonomy exists, and the findings of the case studies cannot be transferred directly. However, evidence from several studies indicates that local governments in different legal settings have a significant role to play despite national differences in terms of the magnitude of local autonomy from the national state. The findings from this study, for example, correspond with (Cramer, 2020), who analysed the implementation of circular economy programmes in the Amsterdam Metropolitan Area and found that collaboration between multiple partners was a key driving force for change, despite the fact that the national state typically plays a more significant role in the Netherlands than in

Table 4
Modes of governance demonstrated in the two case studies.

	Construction case	Textile case
Self-governance	Using the demolition fund to support selective demolition	Not used
Governing by provision	Using the ownership to the local waste company BOFA as a storage facility for demolished construction materials	Using relationships with the publicly owned waste company to explore the potential for the structure of a future collection scheme
Governing by authority	Using the waste planning and waste management authority	Establishing a pilot collection scheme and implementing changes to the municipal waste management plan afterwards
Governing through enabling	Creating collaboration between local stakeholders in the construction and demolition sector	Not used

Denmark. In Denmark, the municipal ownership over utilities in the solid waste, wastewater and energy sectors is an important asset for creating change. Studies in industrial symbiosis (Branson, 2016; Jacobsen, 2006) and the energy sector (Damsø et al., 2016) illustrate how "governing by provision" can function as a vehicle for change. The same was found in this study, where the municipal ownership of local waste companies influenced collaboration, especially in the construction case, whereby construction materials were stored at a facility owned by the waste company BOFA. Countries where this type of ownership relations does not exist may evidently not have such possibilities for governing by provision.

7. Conclusion

The paper analysed how cities and local governments can contribute to developing a circular economy. The paper used a framework originally developed by Kern and Bulkeley (2006) for studies on climate change mitigation initiatives and utilised this framework to understand circular economy initiatives. The paper analysed two case studies focussing on the recirculation of construction and demolition materials and waste textiles, and for both flows found that changed practices can redirect the material flows and support the transformation towards a circular economy. In both cases, the municipalities collaborated in partnerships with waste companies and knowledge institutions to identify waste streams and to explore pathways for closing material loops. Governing by provision, where the municipalities collaborated with the municipally owned waste company, was in both cases found to function as an important driver for change. The cases indicated that municipalities can play a vital role in organising capacities among local stakeholders and that municipalities can function as an important change agent to support and facilitate the transformation towards a circular economy.

Funding

The research was funded by the Capital Region of Denmark, the Regional Council Development Funds.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Thanks are given to master's students Alexander Sørensen Pazyj, Mads Holmgaard Meyer and Pernille Haagen Larsen, who developed the material flow analysis in the textile case.

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