ARTICLE IN PRESS

Research Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Research Policy

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

Governance for system optimization and system change: The case of urban waste

Markus M. Bugge*, Arne Martin Fevolden, Antje Klitkou

Nordic Institute for Studies in Innovation, Research and Education (NIFU), P.O. Box 2815, Tøyen, NO-0608, Oslo, Norway

ARTICLE INFO

Keywords:
Urban
Waste
Infrastructure
Innovation
Transition
Governance

ABSTRACT

This paper analyses urban waste systems to explore how local authorities can resolve challenges related to climate change, urbanization and resource depletion. The paper investigates how different public governance regimes affect local authorities' ability to move upwards in the waste hierarchy. It identifies three different governance regimes – traditional bureaucracy, new public management and networked governance – and uses the insights from innovation in urban waste in three Norwegian city regions – Oslo, Drammen and Bergen – to illuminate how these regimes possess both strengths and weaknesses in how they affect system optimization and system change. The observed working practices signal that the issue of urban waste systems is perceived as a challenge of system optimization rather than system change. Viewing this as a challenge requiring system change would probably have ensured a stronger directionality and a broader anchoring of actors. Such an approach is likely to have arrived at a waste prevention mode earlier than the step-by-step-solutions implemented so far. The paper concludes that there is not one best governance regime, but a need to acknowledge their coexistence and carefully consider the characteristics of the respective regimes in order to arrange urban waste systems for long-term dynamic and sustainable city regions.

1. Introduction

More than half of the world's population lives in urban areas, and this proportion is increasing (Frantzeskaki and Kabisch, 2016). Urbanization, in parallel with population growth, has led to a transformation of rural land into urban areas, a higher consumption of natural resources and an increase in pollution and waste creation. Thus, urbanization presents a challenge for urban waste processing; waste must be managed and processed in such a way that energy is recovered, materials are recycled and reused, and waste is minimized. This challenge is already straining the abilities of many local governments, with food waste and waste from food-related products (e.g. food packaging and other non-consumable material associated with the food chain), causing huge environmental, economic and social problems (Mourad, 2016; Hodson and Marvin, 2010). In total, 1.3 billion tonnes of edible food are lost or wasted annually (FAO, 2011). Moreover, this challenge will only grow more demanding in the future, as worldwide waste production rises: it is estimated to double by 2025 (Hoornweg et al., 2013).

Although most urban areas face similar challenges, the ability of local authorities to handle waste efficiently and sustainably varies significantly – both within and between countries. The objective of this paper is to improve our understanding of why some local authorities are better than others at reducing, reusing and recycling waste; that is, ultimately, to treat waste more sustainably. In order to do this, local authorities need to introduce new and smarter urban waste systems. However, such large (urban) socio-technical systems are highly durable and path dependent, and in consequence, they are hard to change (Geels, 2002). A transition of urban waste systems implies changes in both production and consumption patterns, as well as in policies, technologies, institutions and business models. At the same time, such a socio-technical transition involves coordination across various types of actor groups and across several integrated sectors, such as energy, transport, agriculture and infrastructure (Davoudi and Evans, 2005; Weber and Rohracher, 2012; Uyarra and Gee, 2013).

This paper analyses innovation and sustainability in urban waste systems through the lens of public governance regimes. It identifies three governance regimes – traditional bureaucracy, new public management and networked governance – that influence how decisions, activities and involvement related to urban waste are made and carried out by local authorities. The paper discusses how the three governance regimes possess strengths and weaknesses in terms of "system optimization" and "system change", where system optimization is understood as changes that improve the sustainability or cost efficiency of an existing waste system, and system change is understood as changes that

* Corresponding author.
E-mail addresses: markus.bugge@nifu.no (M.M. Bugge), arne.fevolden@nifu.no (A.M. Fevolden), antje.klikou@nifu.no (A. Klitkou).

https://doi.org/10.1016/j.respol.2018.10.013

Please cite this article as: Bugge, M.M., Research Policy, https://doi.org/10.1016/j.respol.2018.10.013

radically transform the waste system and fundamentally alter and enhance its potential sustainability or cost efficiency. The paper aims to answer the following research question:

How do different public governance regimes affect the dynamics across system optimization and system change in urban waste systems?

To investigate how the three governance regimes affect the potential for effectiveness, innovation and sustainability, the paper presents insights from an analysis of three urban waste systems in different city regions in Norway: Oslo, Drammen and Bergen. The intention is to use the insights derived from the three city regions studied as examples to illuminate how the various governance regimes have implications for innovative and sustainable dynamics across system optimization and system change.

The paper is structured as follows: after this introduction, Section 2 outlines the theoretical background for the paper. In the third section, the research focus of the paper and the applied methods and data are presented. Section 4 presents the case studies: first, a short overview of the political framework conditions is presented, followed by an outline of the three case studies. In the fifth section, the findings are discussed, and, finally, Section 6 sums up and concludes.

2. Conceptual framework

To analyse local authorities' ability to produce system optimization and system change, this paper applies an analytical framework building upon theorizing on (a) balancing between system optimization and system change, and (b) public governance regimes.

2.1. System optimization versus system change in waste

Our conceptual framework distinguishes between two ways of improving urban waste systems – system optimization and system change. Traditional innovation studies focus on how to enable, stimulate and nurture innovation within established industries, sectors and systems in order to foster economic growth, while transition theory investigates how innovation can be directed towards solving pressing (grand) societal challenges. Transition theory employs concepts such as regime change and socio-technical transitions to illustrate that the changes this approach is concerned with are radical and encompass several sectors (the private, public and civic sectors) (Kemp et al., 1998; Geels, 2002; Markard and Truffer, 2008).

When a municipality pursues system optimization, it wants to improve an existing waste system by reducing costs and improving sustainability. For instance, a municipality can work to improve the logistics of the collection and delivery of waste to its incineration plant. This strategy will improve both costs and sustainability by making better use of the installed capacity and by burning waste that might otherwise have been treated less sustainably (e.g. dumped on landfills). When a municipality pursues system change, on the other hand, it seeks to innovate beyond the existing systems, infrastructures and investments in order to climb up the waste pyramid. Fig. 1 presents the waste pyramid, in which different waste treatment options are ranked according to how sustainable they are, with disposal and energy recovery as the less favourable options and recycling, reuse and prevention as the more favourable and sustainable options.

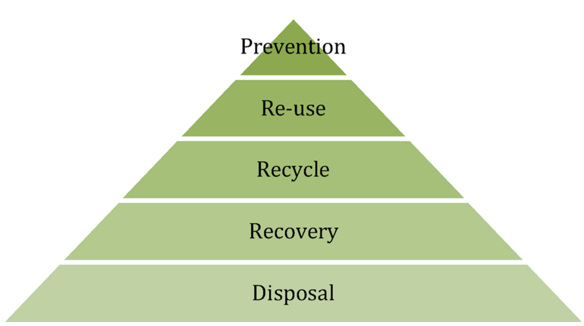

Fig. 1. The waste pyramid.
Source: European Parliament and Council of the European Union, 2008.

A municipality would, according to this model, pursue system change if it replaced an existing system based on waste recycling with a new system aiming for the prevention of waste in the first place by focusing on reuse and waste minimization (Bulkeley and Gregson, 2009; Mourad, 2016). The waste pyramid in this sense constitutes various waste systems that represent fundamentally different logics and ways of treating waste. Moving from one level of the waste pyramid up to another is thus an example of system change.

Although it is possible to distinguish between different levels of the waste pyramid, it is common for waste systems to consist of more than one waste regime that co-exist in different combinations. Today, the most common systems for processing organic waste are based on recycling, in the form of biological treatment systems and incineration. Transitions from one waste system to another may be challenging, as an existing waste system will often tend to be embedded and anchored in certain technologies, infrastructures and institutions (Frantzeskaki and Loorbach, 2010). The transition from landfill (disposal) to incineration (energy recovery) requires investment in incineration infrastructure to capture and exploit the energy from the waste. The transition from an incineration system (energy recovery) to a biological treatment system (recycling) requires new infrastructure, and also altered behaviour from the citizens using the system, as a result of the need for sorted waste streams. Plus, there is a need for a market for the different sorted waste streams (e.g. paper, plastics, glass, metal, textiles) and the products of the biological treatment, such as biogas as a fuel and biosolids as fertilizer (Murray, 2002). But how does recycling relate to reuse and prevention?

2.2. Governance for system optimization and system change

How can governance affect system optimization and system change? Both the innovation and transition literature emphasize that there are various ways in which governance can promote or hamper innovation and transition (Schot and Steinmueller, 2018).

Transition management has been developed as a framework to analyse and structure ongoing governance processes in society (Loorbach, 2010, p.163). In the transition management literature, change is understood as arising through the interaction between strategic, tactical and operational governance activities. These governance activities need to be integrated through reflexivity, a cross-cutting activity (Kemp et al., 2007, p.82). Addressing urban waste involves complex infrastructural systems consisting of technologies, regulations, public services and user practices. In this way, the process represents dealing with path-dependent, interwoven and institutionalized socio-technical regimes that can be hard to change. A transition in an infrastructural system like this implies a fundamental shift of social and institutional components and the design of the physical infrastructure system (Frantzeskaki and Loorbach, 2010; Jonsson, 2000).

In our framework, we will draw specifically on two theoretical contributions – Klein Woolthuis et al.'s (2005) innovation system failure framework and Weber and Rohracher's (2012) transformational failure framework. In line with the theoretical thinking presented above, the innovation system failure framework exhibits factors that can promote or hamper system optimization and the transformational failure framework exhibits factors that can promote or hamper system change.

Klein Woolthuis et al. (2005) identify four structural innovation system failures that can be interpreted as promoting or hampering system optimization: capabilities failures, infrastructural failures, network failures and institutional failures. *Capabilities failure* refers to a lack of appropriate competences and resources at the firm and organizational level that may limit and/or prevent the generation of, access to and exploitation of knowledge. *Infrastructural failure* refers to a lack of physical and knowledge infrastructure due to the large-scale, long-time horizon of operation and ultimately too low a return on investment for private investors. *Institutional failure* refers to an absence, excess or shortcoming of the formal institutions, such as laws, regulations and standards (particularly regarding intellectual property rights [IPR] and investment), or a lack of informal institutions such as the social norms and values, culture, entrepreneurial spirit, trust and risk-taking that might impede collaboration for innovation. Finally, *network failure* refers to the intensive cooperation in closely tied networks that leads to myopia and the lack of an infusion of new ideas or a limited interaction and knowledge exchange with other actors, which can inhibit the exploitation of complementary sources of knowledge and processes of interactive learning. The four dimensions constitute the central elements of governance necessary in order to facilitate system optimization.

Weber and Rohracher (2012) identify four possible types of policy failure that can be interpreted as promoting or hampering system change: directionality failure, demand articulation failure, policy coordination failure and reflexivity failure. *Directionality failure* refers to a deficit in creating a shared vision and in pointing innovation efforts and collective priorities in a certain direction to meet societal challenges. *Demand-articulation failure* refers to a deficit in anticipating and learning about user needs, resulting in inappropriate and misleading specifications guiding development through, for example, procurement or policy programmes. *Policy coordination failure* refers to a deficit in managing and synchronizing the inputs from different policy areas to meet societal challenges. Policy coordination requires increased administrative capacity and might include coherence between policies at the international, national, regional and municipal levels (vertical coordination failure), or across different sectors (horizontal coordination failure). This also includes the right timing and sequence of different policy interventions. *Reflexivity failure* refers to a deficit in the learning feedback loops and the ability to continuously monitor the progress of ongoing innovation processes and to adjust the course of action underway accordingly.

In our conceptual model, we will use Klein Woolthuis et al. (2005) and Weber and Rohracher's (2012) categories not as failures, but as elements of governance that promote system optimization and system change. In this sense, we will describe and discuss the different governance regimes according to their ability to build and mobilize capabilities, infrastructure, networks and institutions in ways that foster system optimization, as well as according to their ability to direct innovation, articulate demand, coordinate policy and promote reflexivity in ways that facilitate system change. The next task for our conceptual model is to be able to explain how system change in urban waste management may play out in various governance settings. In the following, we will therefore see how different governance regimes may affect innovation in urban waste management systems.

2.3. Governance regimes conditioning innovation dynamics in the public sector

In this paper, we are interested in the governance of urban waste systems and will investigate how different governance regimes affect innovation dynamics in urban waste systems. To do so, we will follow Hartley (2005) and distinguish between three governance regimes or paradigms of public governance that all have their respective innovative characteristics. The three are (1) traditional bureaucracy, (2) new public management, and (3) networked governance. The three regimes can be seen as responses to different historical phases and societal challenges that require different solutions and institutions. The three regimes represent ideal types and in real life a mixture of them usually exists (Smith, 2007; Weber, 1978 [1922; Weber, 1978 [1922]). The governance regimes possess various characteristics and rely on different types of knowledge and principles of organization, and have various forms of expected behaviour and outputs in terms of innovation. Each paradigm may be associated with its respective ideologies and historical epochs, but may also be seen as competing and simultaneous. The three governance regimes explain how we can expect an urban waste system to work within different governance settings.

2.3.1. Traditional bureaucracy

The traditional bureaucracy paradigm is dominated by a state logic. This paradigm is based upon a legislative, bureaucratic and rule-based approach to the provision of public services. This paradigm was particularly important in the post-war period until the early 1980s. The bureaucracy is based on a stable context and the focus on adhering to legislation and following standardized procedures (Weber, 1978 [1922; Weber, 1978 [1922]). Such a system performs well in terms of sustaining the status quo, which is often the aim (Hess and Adams, 2007). The population is primarily seen as clients or as taxpayers. In terms of organization, this paradigm is understood as being based upon the state as the producer of services through hierarchies and silos. There tend to be clear boundaries between the public and the private sector. The bureaucracy is based upon the centralized and authoritative knowledge of professional public servants. In a similar vein, knowledge development in this governance regime tends to be accomplished by researchers internally, within the public administration. Innovation projects in this paradigm tend to be carried out on a large scale and often at the national level. The definition of problems and needs is done by professionals, who provide standardized services to the population. Policymakers are seen as commanders implementing policies top-down, which limits the possibilities for continuous improvement through open and iterative processes of user-driven innovation.

In relation to urban waste systems, we expect that a bureaucratic model of governance constitutes an organization where the municipality controls and carries out most of the waste-related activities in-house. Typically, the municipality will be responsible for most of the public service provision itself, and engagement with the civic sector is relegated to local politicians. In terms of innovation dynamics, traditional bureaucracy does not represent clear incentives for incremental innovation or the continuous improvement of services. On the other hand, such a system implies a stronger potential for system change, when politicians signal a clear desire for a more sustainable waste system.

2.3.2. New public management

New public management is dominated by market logic. Since the late 1980s, the call for the public sector to become more productive and innovative has been a central part of the rationale behind the transition to new public management (NPM) (Hood, 1991; Parsons, 2005). The underlying principle for NPM was public choice theory (Aucoin, 1990) and increasing market orientation for the public sector (Self, 1993). Aucoin (1990) identified three aims for the NPM era. First, NPM aimed to diminish the role of the state and to make the bureaucracy more responsive to the political apparatus. Second, it aimed for greater productivity in the public sector by applying techniques derived from the business sector. Third, it began viewing the citizen as a customer and a service recipient. These factors led to clear boundaries between policy formulation and service provision, and a blurring of the boundaries between public and private service provision. The NPM regime is based on competition between atomized agents (often within public service provision) and governance and organization is structured around market principles. Moreover, NPM has favoured expertise from economics and management as the dominant knowledge sources, and knowledge development is typically outsourced to external (private) knowledge providers. Innovation activities are oriented towards exploitation and finding best practice within established frameworks. The outcomes of NPM have been manifold and much debated (Osborne, 2006; Hess and Adams, 2007; Schubert, 2009).

In terms of urban waste systems, we expect that NPM implies a

Table 1
Different governance regimes and their implications for optimization and system change in urban waste.

	Traditional bureaucracy	New public management	Networked governance
Infrastructure	Publicly funded and accomplished large-scale investments and development projects	Public-private projects with shared funding and revenue models. Well-defined contracts with given characteristics and/or functions of solutions. Price oriented	Orchestration of multiple actors and with a focus on the exploration of new possibilities across these, e.g. business development based on data collected from mobility/consumption patterns of consumers/users
Institutions	National public research and innovation funding bodies	Public control agencies to oversee adherence to contract agreements. Practice of collecting market feedback. Efforts at copying best practice	Exchange schemes, labour market mobility; sector-wide strategy processes involving private, public and civic sector, e.g. Health 21 or Forest 22 in Norway
Networks	Blurred boundaries between politics, administration and service provision; Supporting networks of similar actors; linking firms to higher education institutions. Industry networks; strengthening specialization through industry clusters	Public-private partnerships; contractual practice of outsourcing through public procurement with limited interaction across purchaser and contractor; industry associations; emphasis on the interface between service delivery and consumers	Subsidy for cooperative R&D; supporting knowledge networks across disciplines and sectors
Capabilities	Obtaining professional knowledge in-house in public agencies; upgrading of internal R&D capacities	Outsourcing services to private experts/ contractors. Public subsidy of private R&D; strengthening the absorptive capacity of firms; law and economics are important skills in public administration; emphasis on user experience and industry needs	Mediation between research based and user driven/ challenge oriented innovation. Objective of anchoring knowledge development in societal needs, e.g. grand challenges & responsible research & innovation
Directionality	Politically set (long-term) strategic societal goals	Public administration formulating contracts for public service provision reflecting political objectives	Collaborative setting of common goals. Broad anchoring of problem formulation and system change solution. Potentially low implementation force
Demand	Top-down formulated societal demand. Formulated by knowledge in-house. Able to address system change. Information campaigns	Demand for public waste services formulated in specific tenders. How can the service be accomplished cost-effectively? Tends to be aimed at system optimization in terms of managerial and organizational innovation	Demand may refer to large-scale societal needs or to specific services. Demand formulated by broad constellations across public, private and civic actors. Public procurement. (Living lab) experiments to facilitate joint learning processes
Coordination	Good potential for coordination due to blurred boundaries between politics, administration and service provision	Clear boundaries between politics, administration and service provision; clear specifications of contents in private contracts	Public–private–civic partnerships, exploration across actors and sectors. Multi-scalar coordination. Extensive coordination and dialogue. May be resource-intensive
Reflexivity	Feedback loops and reflexivity across politics, administration and service provision in the municipality. Reflexivity restricted to public sector	Clear boundaries across politics, administration and service provision, and contract orientation together represent limited incentive for joint reflexivity. Reflexivity associated with customer satisfaction, market analysis and feedback and optimization of existing services	Joint reflexivity and learning across public, private and civic sectors. Keep open portfolios of solutions. Monitor, evaluate or adjust transformational change

system of governance where the municipality outsources several waste-related activities to private companies by issuing highly specified public tenders. Typically, the municipality will favour price over innovative solutions when they chose suppliers. Such a governance regime is likely to stimulate innovation in the functions and services specified in the public tenders. Such innovations are likely to relate to the organizational, operational or managerial aspects of the services that are provided. However, the (private) contractors have no incentive to question or problematize the system in which they operate. Governance based on NPM is thus expected to be effective within the specified boundaries but is not anticipated to foster system change.

2.3.3. Networked governance

The networked model of governance is dominated by a "community logic" and represents a systemic and relational approach to enhancing innovation in the public sector. This governance approach could also be seen as a response to the growing complexity of modern society. Societal challenges often span several public and governmental domains and accordingly the solutions to these challenges need to be found through collaboration across sectors. As such, the objectives of the networked governance regime have a pronounced focus on the societal outcomes of innovation. In such innovative work, the benefits of the outputs and outcomes may serve actors other than the ones who arrange for the inputs. In this approach, experimentation is called for in various local contexts. Networked governance involves collaboration and co-creation from several actors, such as public managers, bureaucrats, private stakeholders and the users of public services. Innovation activities are geared towards exploration and novel solutions across public, private and civic realms. Innovative efforts thus go beyond organizational boundaries and distinguish innovation in the public sector from innovation in the private sector (Moore and Hartley, 2008). The role of public managers is not necessarily to accomplish all public innovations themselves, but rather to facilitate and align constellations of diverse actors to address various societal challenges. Such a form of enabling collaborative innovation thus becomes a form of meta-governance (Sørensen and Torfing, 2011) or orchestration (Kuhlmann and Rip, 2014). Such broad collaborative constellations might call for a new set of agents, able to bring different actors together and to bridge their respective diverging objectives and challenges. Collaborative innovation also has a focus on innovation as a continuous phenomenon that is rooted in all public sector activities, i.e. an institutionalized form of innovation (Albury, 2005; Eggers and Kumar Singh, 2009; Sørensen and Torfing, 2011).

Although networked governance does not capture the prescriptive, selective, normative and pro-active role often prescribed by the transition management literature, it appears appropriate in terms of its broad coverage of diverse societal actors. With reference to urban waste systems, we expect that a networked model of governance will imply an organization where the municipality facilitates and orchestrates interaction and synergies across the actors involved in the collection and processing of organic waste both from the public and private sector. Such an interdisciplinary and collaborative form of innovation might entail both incremental innovations contributing to the optimization of existing systems and more radical innovations contributing to system change.

2.4. Summing up the analytical framework

Having introduced the different building blocks in our conceptual framework, we will now sum up and illustrate how they interrelate and constitute a matrix for the analysis of urban waste processing in the three city regions.

The two sets of four policy dimensions (i.e. infrastructure/institutions/networks/capabilities, and directionality/demand articulation/policy coordination/reflexivity) point to central dimensions for policy to balance between system optimization and system change. We therefore want to apply these in our analysis of how the three governance regimes (traditional bureaucracy, new public management and networked governance) condition innovative behaviour in urban waste processing. In this sense, the eight policy dimensions will constitute a way to structure the analysis of how the three governance regimes affect innovation in urban waste systems. We assume that the transformation of the incumbent system requires a transition from one system to a new system. This transition is guided by directionality, demand articulation, policy coordination and reflexivity, but will lead to a new system, which again requires new constellations of system characteristics, such as infrastructure, institutions, networks and capabilities, and this system again needs to develop qualities that allow continuous system transformations.

Table 1 summarizes and illustrates how we expect the different policy dimensions to bear implications for innovation dynamics in urban waste processing within the three governance regimes. Based on the matrix in Table 1, we would expect to see how the three governance regimes have different implications for the innovative dynamics of system optimization and system change. Although new public management appears well suited to address system optimization, traditional bureaucracy appears best at directing top-down system change, whereas networked governance appears best suited to address bottom-up system change. Fig. 2 illustrates the conceptual framework visually.

3. Research objectives and methods

We apply a comparative case study approach for this paper. Case study analysis can contribute to theory development in different ways, such as testing a conceptual framework or identifying contradictory evidence (Eisenhardt, 1989; Andersen, 1997). Our comparative case study attempts to test our conceptual framework on the innovative dynamics of urban waste management in three metropolitan regions in Norway: Oslo municipality, the capital of Norway; the region around the neighbouring city Drammen; and the region around the second largest city of Norway, Bergen.

The selection of the three city regions for the comparative case study analysis was motivated by an attempt to find city regions with different governance solutions, regions of different but comparable sizes, and regions with different economic specializations to deploy the results of the respective waste processing systems. External experts advised us in the sampling of relevant cases for our paper. While the Oslo and Bergen regions are strong urban regions with larger cities at the centre, the Drammen region is a collaboration of a medium-sized city and several smaller municipalities. While considerable levels of agriculture exist in the Oslo region and in the Drammen region, in the Bergen region this is much less developed. Here, there is more of a focus on aquaculture.

The contrasting governance solutions are connected to the three models of governance, which are used as ideal type models for the analysis of the three case studies. All three city regions have elements of NPM as their governance structure, but combine this regime with the two other governance regimes in different ways: Oslo has elements of NPM, but with an emphasis on a traditional bureaucracy regime; Bergen emphasizes NPM, but has adopted some bureaucratic elements; Drammen has adopted elements from both NPM and network governance. The different size of the municipalities is compensated for in the two smaller cities, Bergen and Drammen, through the involvement of the surrounding municipalities in the waste management of the central municipalities, which is a quite common organizational solution for municipal tasks involving larger infrastructures.

The data collection is based upon interviews, participation in policy and industry seminars and document analysis. For the case studies, explorative and semi-structured interviews with key stakeholders and representatives of the respective waste management agencies and involved firms have been conducted. We interviewed fourteen representatives from the following ten organizations and their departments: Avfall Norge, Østfold Research, Oslo municipality Department of Environment and Transport, Oslo municipality Waste-to-Energy Agency, Oslo municipality Agency for Waste management, Bergen region's inter-municipal waste management company BIR (Bergensområdets Interkommunale Renovasjonsselskap), Bergen municipality urban environment agency, Drammen region's inter-municipal waste management company RfD, Lindum AS and NorgesGruppen/ASKO. In addition, we spoke with a representative of the national waste organization and renowned researchers in the field of food waste. In total, we conducted interviews with 11 organizations and their departments. Most of the interviews were conducted face to face and lasted for about 1.5 h. The interviews were recorded and transcribed subsequently. The names of the interviewees are anonymised. We organized two workshops on the subject, one with researchers in the field (November 2016) and the second an open workshop with experts from the industry, public administration, NGO and research areas (November 2017).

In addition to the transcribed interviews and workshops, document analyses of reports and municipal strategies and media analysis have also constituted part of the data collection for the case studies. Finally, field trips and participation at industry seminars and conferences have helped inform the study.

In the next section, a historical and political context is outlined, followed by short case study narratives that explain the main features of

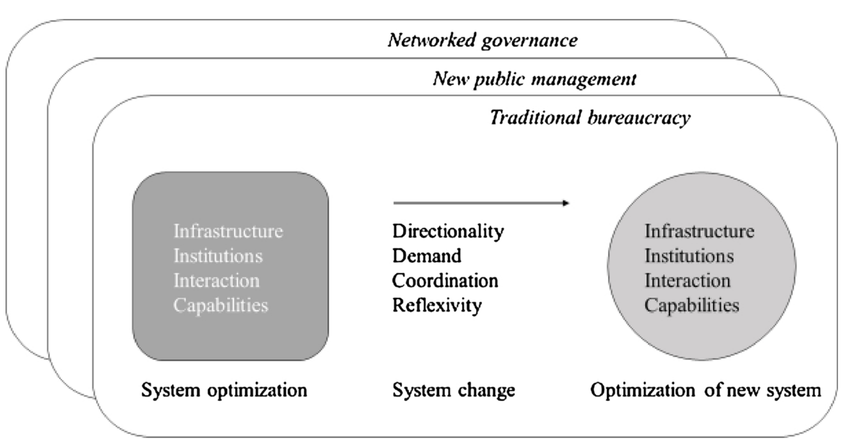

Fig. 2. Illustration of analytical framework.

the three cases.

4. A case study: urban organic waste

4.1. Processing urban organic waste (a historical perspective)

Traditionally, urban organic waste has been addressed as a problem and not as a resource. Organic waste in cities had to be collected to avoid pollution and sickness. Two infrastructure systems evolved in urban areas for this purpose: sewer systems and landfills. The landfills occupied land areas and caused the pollution of ground water, air, lakes and rivers. An implication of the widespread use of landfills was that urban waste was not sorted and any resources could not be recycled or recovered easily (Gee and Uyarra, 2013). A low percentage of all food waste was composted: much of it ended up in landfills and represented a large part of the total municipal solid waste (FAO, 2011).

In the 1960s and 1970s, urban waste was increasingly incinerated to reduce the use of landfills in Europe. This contributed to air pollution and required the use of very high temperatures and the installation of advanced filter systems. The by-product of the incineration, the ash, still had to be stored in landfills. The incineration of mixed urban waste also implied a loss of potential resources that could be recycled or recovered.

The only way to achieve the recycling and recovery of waste resources in cities is to sort the waste streams and to manage them separately. For each waste stream, different routes of recycling or recovery have to be developed. This includes: the sorting and disposal of waste streams by the citizens or other users either at the site of the households, i.e. point of origin, or at decentralized collection points; the transport of the waste streams to different locations where they are further processed; and then the distribution of the new products to potential users in the cities or around the cities. Succeeding the objectives of recycling and recovery, waste prevention has emerged as the most significant contribution to more sustainable production and consumption patterns (Bulkeley and Gregson, 2009; Mourad, 2016). The integration of waste prevention and waste management has been addressed in other areas of waste as well, such as electronic waste (Lauridsen and Jørgensen, 2010).

4.2. Political framework conditioning the case studies

Innovation towards more sustainable urban waste systems in the three municipal cases has been conditioned by political processes at both national and international levels. In Norway, the Ministry of Climate and Environment issued a strategy that addresses waste reduction, waste reuse, recycling and energy recovery (Miljøverndepartementet, 2013) in compliance with the EU landfill ban from 2009, the EU Waste Framework Directive (European Parliament and Council of the European Union, 2008), and the deployment of new technologies, such as biogas production for handling organic waste as a resource (Klima- og miljødepartementet, 2014). The ministerial strategy was then accompanied by a government report on waste as a resource (Klima- og miljødepartementet, 2017b) and an agreement on reduction of food waste between the authorities and the food industry (Klima- og miljødepartementet, 2017a).

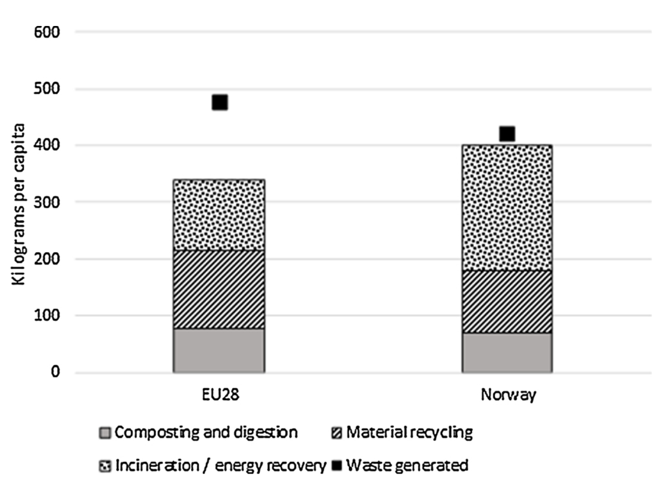

Fig. 3. Municipal waste in Norway and the EU28 by waste treatment operation, 2015 Source: Eurostat data.

The EU Waste Framework Directive established a waste hierarchy – prevention, reuse, recycling and recovery for other purposes such as energy and disposal – and confirmed the "polluter pays principle" (European Parliament and Council of the European Union, 2008). The directive highlighted how national authorities have to establish waste management plans and waste prevention programmes, and how waste management must be carried out without any risk to water, air, soil, plants or animals, without causing a nuisance through noise or smells, or harming the countryside or places of special interest. The directive introduced recycling and recovery targets to be achieved by 2020 for household waste (50%) and construction and demolition waste (70%). According to the Norwegian Ministry of Environment, the EU Waste Directive was fully applied in Norway (Miljøverndepartementet, 2013, p.11). National objectives for waste and recycling include the decoupling of economic growth and the growth of waste, and a recycling rate of 75% in 2010, with an aim of increasing this to 80% (Miljøverndepartementet, 2013). In the 1990s, restrictions were introduced for storing wet organic waste in landfills, and since 2009 this has been banned. Wet organic waste now should be treated biologically, either as compost or as biogas (Miljøverndepartementet, 2013, p.15).

The Norwegian Pollution Act[1] regulates the municipalities who are responsible for the collection and processing of household waste. Private businesses are responsible for processing their own waste unless it is recovered or otherwise used. The municipality's handling of household waste is self-financing through fees and governed by waste regulations.[2]

The main difference between Norway and the EU28 (see Fig. 3) is that in Norway there is less waste generated per capita, and at the same time a much higher share of this waste is treated. Under waste treatment, we include composting and digestion (including biogas), material recycling and incineration, but not landfill. The considerable gap between waste generated and waste treated for the EU28 (136 kg per capita) points to a lack of treatment capacity and landfill solutions. More importantly, the share of incineration as one of the treatment solutions is much higher in Norway (53%) compared to the EU28 (27%). This means that Norway still has a lot of potential in terms of moving up the waste hierarchy.

Table 2 shows how the three city regions vary in size and in terms of waste production and waste processing and recycling. It shows how Drammen has a considerably higher share of material recycling than Oslo and Bergen.

4.3. Urban waste in the Oslo region

The municipality of Oslo has developed a *traditional bureaucratic* waste processing system with elements of NPM to accomplish specific sub-tasks. Two municipal agencies are responsible for organizing the collection, transport and recycling of municipal waste (Renovasjonsetaten) and for energy recovery of the municipal waste (Energigjenvinningsetaten – EGE). In addition, a third municipal agency, Bymiljøetaten, has responsibility for the planning and

[1] Lov 13.03.1981 nr. 6 om vern mot forurensninger og om avfall (forurensningsloven), last changed 1 October 2015.

[2] Forskrift 01.06.2004 nr. 930 om gjenvinning og behandling av avfall (avfallsforskriften), last changed 29 October 2015.

Table 2
Selected indicators on waste generation in Oslo, Drammen and Bergen, 2015.
Source: SSB Kostra.

	Oslo	*Bergen*	*Drammen*
Number of inhabitants in the core city	975,744	252,772	115,137
Number of inhabitants with the interacting municipalities*		320,000	190,000
Area in km^2	265.7	86.5	51.0
Household waste per inhabitant in kg	336	422	531
Delivered to material recycling and biological treatment per inhabitant in kg	130	102	244
Share of waste delivered to material recycling, including biological treatment in %	39	24	46
Share of waste delivered to incineration in %	58	70	51
Share of waste delivered to landfills in %	3	N/A	0

* Information provided by BIR and RfD.

development, management and operation of municipal urban spaces in Oslo. The agency is also responsible for the environment in the city, such as the quality of air, water, soil etc. These agencies are *coordinated* by the vice mayor for environment and transport. The municipality has been central in *directing the system towards greater sustainability* by establishing a biogas plant for municipal food waste and by launching plans for carbon capture and storage for the energy recovery plant.

The municipality of Oslo has implemented a two-bin system consisting of one bin for plastic, food waste and residual waste, collected one to six times a week, and one bin for paper collected one to four times a month. In addition to this, there are 910 collection points for glass, metals and textiles across the city. Moreover, the city has collections for hazardous waste, three large recycling stations (Haraldrud, Grønmo and Smestad), two mobile recycling stations and a regular collection of garden waste. The municipal waste processing system (Fig. 4) includes the optical sorting of waste resources from private households, i.e. plastics, food waste and residual waste. Food waste is collected in green bags, plastic in blue bags and residual waste in neutral bags, and all the bags are disposed of in the same household waste bin.

After the collection of household waste in the waste bins, it is delivered to a large sorting plant at Haraldrud in Oslo. There, the three types of waste bags are sorted automatically by optical sensors: plastic waste goes to fine-sorting and recycling in Germany, food waste goes to the biogas plant in Nes in Romerike (outside Oslo), and the residual waste goes to incineration, with an energy recovery process after sorting out metals. The ash residuals are sent to a landfill. The municipality plans to develop the incineration plant as an industry pilot for carbon capture and storage. The biogas plant at Nes was opened in 2013. It has the capacity to process 50,000 tonnes of food waste annually. The gaseous biogas is upgraded to liquid biogas (LBG). This process extracts CO_2 and reduces the volume of the biogas. The municipal biogas plant also produces bio-residuals, which are sold to neighbouring farmers as fertilizer. The LBG produced is used for the public transport system of Oslo. Fig. 4 gives an overview of the parallel systems of waste management in Oslo in which the public and private sector collect and process their respective waste streams in separate systems.

Over the last ten years, a large private actor, ASKO, has specialized in processing the food waste from private businesses. ASKO is the wholesale and logistics business partner of one of Norway's largest retailers, NorgesGruppen, which includes grocery stores, restaurants, kiosks, gasoline stations and hotels. The recycling element of the logistics business includes the collection of food for redistribution by a charity organization to reduce food loss (Matsentralen), the return of bottles and boxes, cardboard and paper recycling, plastic recycling and the reuse of different types of containers etc. ASKO's trucks deliver food to the retailers and bring their sorted waste products back for recycling on the return trip. This practice avoids driving empty trucks and reduces fuel costs and emissions. The collected waste streams are material-recycled; food waste as biogas, plastic waste as plastic resource, cardboards and paper for paper recycling etc. Plastic waste is delivered to Folldal Gjenvinning, which produces a recycled interim product, a plastic granulate which is used as a resource in NorgesGruppen's plastic bag production. The sorting of the plastic waste from private businesses is more fine-grained than the public household plastic waste, where different types of plastic are mixed, which allows a lower quality of the recycled interim product.

The introduction of the recycling system in NorgesGruppen started

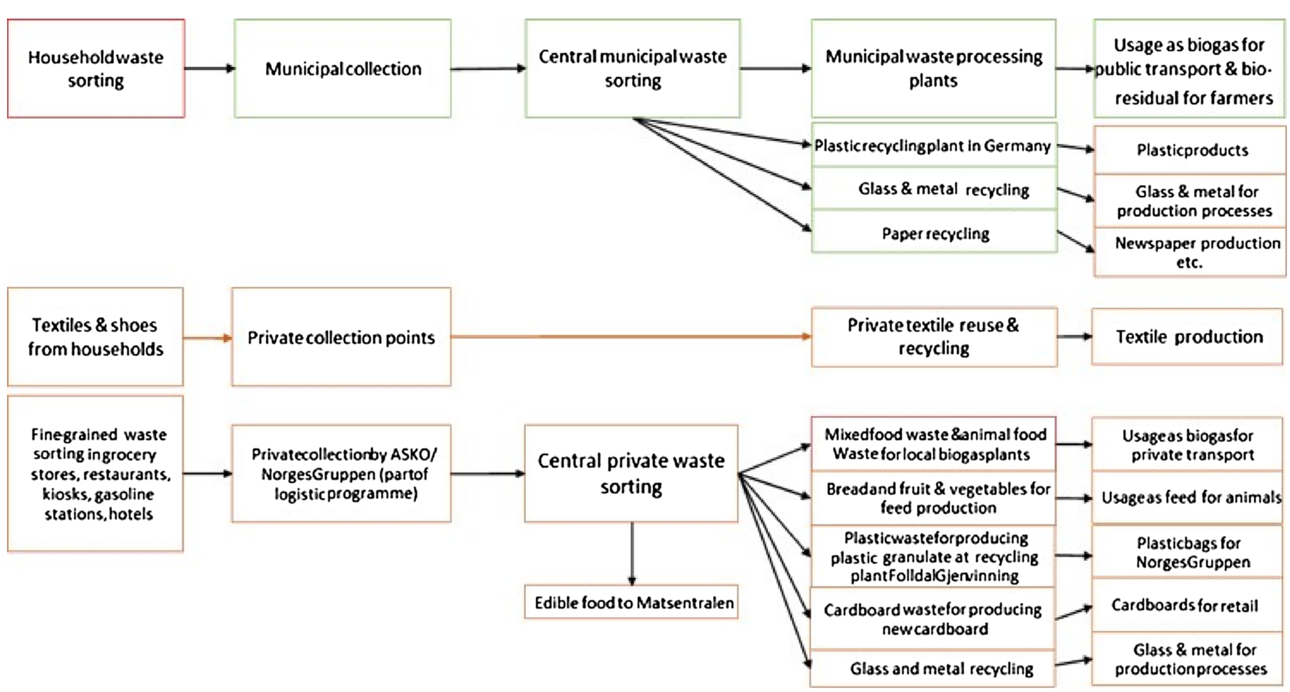

Fig. 4. The Oslo case: parallel systems of waste management in Oslo.
Note: The different colours symbolize the waste management spheres: green for municipal tasks and brown for private activities.

in grocery stores, from 2004 to 2009, with an ambition of learning the fine-sorting of waste streams. In 2010, the first pilot including the establishment of new value chains based on the sorted waste streams was initiated. After the sorting routines were well-established, this was implemented by all ASKO enterprises from 2011 to 2012, and ASKO took over the logistics and transport of the sorted waste resources.

Commodity markets have been established for the interim products: a secondary raw material market for items such as cardboard, plastics and metals. For these waste fractions, ASKO can generate revenues, while in food waste this is more challenging. Currently, ASKO is working with separating two types of food waste, with different objectives: bread, fruit and vegetables for feed production, and other food waste – mixed food waste and animal food waste – for biogas production. This can be done because the food waste from private businesses is not mixed in the same way as the food waste from households; e.g. bread that is not sold can be used as a resource for feed production. The biogas fraction is used in a large number of local biogas facilities. There is a conflict between the deployment of waste resources for energy on the one hand and for recycling, including feed production, on the other. ASKO has decided to prioritize environmental investments instead of economic investments and believes that this can also be legitimized economically with a longer-term perspective.

Besides the large actors such as the municipal administration and the large private companies such as ASKO, there are also several smaller niche projects that are attempting to exploit organic waste for new purposes, such as utilizing coffee grounds from coffee shops in the production of mushrooms or soap, or establishing low-priced lunch restaurants based on food that would otherwise have been thrown away.

4.4. Urban waste in the Drammen region

Drammen is part of a regional collaboration between nine municipalities. By the end of the 1990s, the municipalities started to sort waste. The municipalities developed a hybrid between NPM and a networked governance model for their waste system. The collaboration is organized by RfD, an inter-municipal company specializing in public services for waste management in these municipalities. RfD is a contracting organization with 20 employees, while the operational work is performed by private contractors. The main criteria for deciding about contracts are price (60%), the environment (20%) and service quality (20%). RfD owns seven recycling stations that are operated by different enterprises, of which the most important is Lindum AS. The transport of waste is also outsourced, and the contractor gets access to trucks from another private enterprise, which owns all the garbage collection trucks. According to RfD, the advantages of organizing the waste management system in such a way are efficiency, competence and larger contracts. However, this is questionable, because the contractor, RenoNorden, won the contract owing to very low bids compared to the other competitors, but then had to buy new more environment-friendly equipment to keep the contract. Therefore, the company did not make any profit and went bankrupt in September 2017 (Hovland, 2017). The focus of RfD on price-based outsourcing does not support a system change in waste management. A higher focus on the environmental aspects could have favoured the demand for more systemic changes.

In the city of Drammen, waste processing evolved historically from a regional waste plant for recycling in 1997, when Lindum was established as a municipal company. As illustrated in Fig. 5, Lindum can be seen as reflecting a *network governance model,* collaborating with many actors within and outside the Drammen region. In 1997, Lindum had eight employees and a turnover of NOK8 million. In 2001, the company was converted into a shareholder company, owned 100% by Drammen municipality. With this change, a stronger market orientation became possible. In 2008, Lindum gained the status of an industrial group, including a number of companies. The industrial group now includes companies all over southern Norway. In 2016, Lindum had about 230 employees and a turnover of about NOK467 million.

Since 2001 the company has diversified both regionally and regarding the different parts of the waste processing system. Lindum covers all parts of the waste pyramid: waste reduction, reuse, material recycling, energy recovery and the landfill of contaminated soil, but the company consciously aims to take the waste away from landfill and energy recovery towards the upper and more valuable parts of the waste hierarchy. Traditionally, the management of contaminated soil was the most important business area, but in the last few years, organic waste and recycling have become much more important business areas. This especially applies to organic waste – Lindum has access to organic household waste, industrial food waste and manure – and it can select between three types of treatment: composting, biogas and incineration. The first two options allow soil improvements and are therefore preferred, while incineration is used less for such resources.

Important facilities handling organic waste are located in Drammen and in a neighbouring region outside the city of Tønsberg, where a new plant – “the magic factory” – was opened in autumn 2016. The biogas plant is a result of a regional cooperation between several municipalities, the county of Vestfold and the agricultural and food industries in the region. The biogas plant is owned and financed by the municipality of Tønsberg, while the plant was designed and built by Greve Biogass AS, a shareholder company owned by different municipalities in Vestfold and Grenland. The plant is operated by Lindum and processes food waste from households in the larger region (Vestfold, Grenland and the Drammen region) and industrial food waste and liquid manure from the agricultural industry, used as a substitute for process water. The products are biogas and organic fertilizer.

Such a system of biogas plants and composting facilities cuts across several sectors, such as agriculture, the food industry, energy, transport, sanitation, infrastructure and construction. For this reason, it is also a challenge to reach the public funding agencies, which are often organized within traditional sectoral boundaries.

The ability to draw upon different sectors and residual raw materials, and to produce several types of products in such an integrated system, helps to ensure that Lindum manages to lower the costs of processing waste. This intersectoral cooperation enables the company to compete on price and win contracts. One of the main reasons for this competitiveness is that the selection criteria in public procurement processes often emphasize price to a greater extent than safety, quality and sustainability. An interdisciplinary and intersectoral approach arranging for more localized and self-sustained integrated systems might thus be more effective than simply reducing transport costs due to environmental concerns.

Lindum AS has developed a broad process where the management of urban organic waste has shifted from producing heat towards producing high value vermicompost and biogas. The exploitation of the vermicompost is integrated with the urban environment in greenhouses, on rooftops and on balconies in new quarters of Drammen. Here, interaction with architects in the development of new types of greenhouses has been important. Lindum has taken part in European research projects to develop greenhouses that are not dependent on external heat.

Lindum also has plans to develop and build local mini-biogas plants within the boundaries of certain residential complexes. In this way, there is a trend for households to become more self-reliant and independent, and Lindum's product range is moving from being dependent on access to the waste to increasingly become a provider of decentralized and integrated technological systems for processing household waste. Lindum thus seems to be shifting from being directly involved in the processing of waste to a new role where it develops and offer decentralized solutions for processing systems of urban organic waste. Decentralized solutions would imply that the local households would be given a more direct responsibility for the quality of the sorted waste streams in order to achieve good yields of biogas and fertilizer to be used in their own green spaces, gardens and balconies.

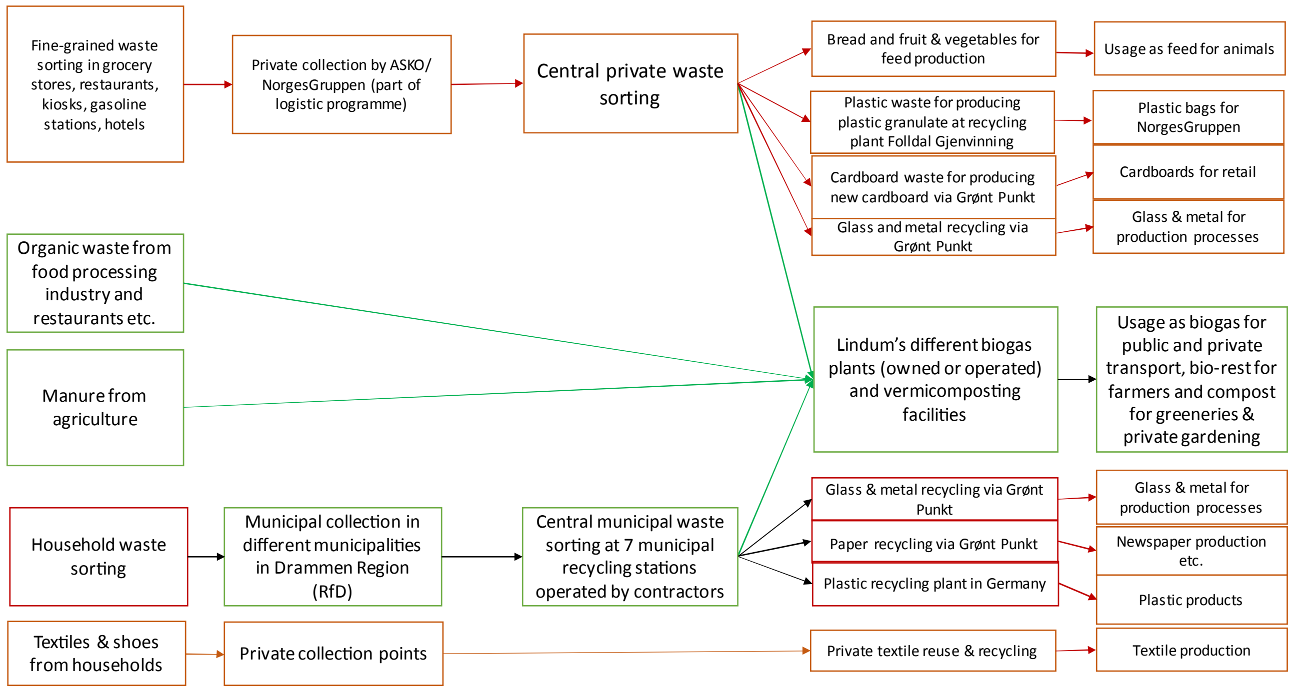

Fig. 5. The Drammen case: integration of municipal and private systems for organic waste management.

The Drammen case exemplifies how different regions have different profiles and characteristics that affect the potential and scope for the recycling of organic waste; that is, they are geographically conditioned. While in the region around Drammen and Tønsberg, waste from cattle holdings and the meat processing industry are important sources of various types of organic waste, this is different on the western coast, as our next case study will show.

4.5. Urban waste in the Bergen region

In Bergen, municipal waste processing has gone through different stages, reflecting all three governance regimes. The main actors in the processing of urban waste in the municipality of Bergen are the municipality itself and the publicly owned enterprise BIR AS. BIR was established in 1996 by the municipality of Bergen in cooperation with the surrounding eight municipalities. BIR is therefore responsible not just for the inhabitants of Bergen, but also for the inhabitants of all nine municipalities; in total, about 320,000 inhabitants. BIR was made into a corporation in 2001.

As illustrated in Fig. 6, BIR is structured according to a group model and has two main divisions: (1) the public service division, the only provider of waste processing services for private households (BIR Private AS), and (2) the enterprise division (BIR Enterprise), which competes with private waste management companies in the market. BIR AS has all rights reserved by the owner municipalities for the processing of household waste and for the incineration of municipal solid waste. The two divisions have set up subsidiaries to accomplish specific tasks. The enterprise division has subsidiaries for the collection and processing of industry waste, for paper sorting and for the underground waste transportation system. BIR also owns about half of the shares of the company that produces and sells district heating, using waste energy from BIR's incineration plant.

BIR's aim is to ensure access to waste and to ensure that BIR AS carries out its municipal obligations under the Norwegian Pollution Control Act § 30, which deals with household waste. BIR's shareholder agreement between the municipalities is an exception to the law on public procurement. For both BIR's own rights (the collection and processing of household waste) and exclusive rights (the collection and processing of municipal solid waste) it is required that the tasks have to be performed at full cost.

BIR was established after a period when landfill was the dominant design for municipal waste processing in the region and throughout Europe. In the early 1990s, Bergen's landfill site at Rådal outside the city became full, and the municipality of Bergen had to signal to the surrounding municipalities that from 1995 this service would no longer be available and more sustainable solutions should be found. For a short period, municipal waste was deposited in a different landfill, but in 1999 a municipal waste incineration plant started operations at Rådal. Since 1998, a focus on providing district heating for Bergen was prioritized and the development of Bergen's district heating system is still under development.

The importance of the different transformational dynamics is illustrated very well in Bergen's waste collection project, BossNett. A major issue for Bergen is the collection of waste in the historic centre of the city. Narrow streets and old infrastructure make this task very challenging, both in setting up waste bins and in transporting the waste for further processing. BIR therefore lobbied for other solutions, and in 2008, the municipality of Bergen gave the directive and decided to develop an innovative pipeline system below the surface to collect and transport waste in the centre of Bergen, the so-called waste-network, known locally as BossNett. This task was assigned to BIR by the municipality. However, this was done without considering if the necessary competencies for this task existed in the organization, and without guiding the enterprise in the fulfilment of the task. In 2013, it became clear that the accomplishment of this task required very different competences in BIR than the organization actually possessed, in addition to stronger steering by the municipality. Addressing this need, a new position was established in the municipality that had a bridging and coordinating function between the municipality and BIR. This person had very relevant experience and competences and helped to ensure the changes needed in BIR, coordinating different infrastructure changes such as waste collection and transport, water and sewage, electricity and fibre cables. At BIR, new personnel with competences from relevant sectors, such as the sewage service, also joined. Ensuring procurement competence for hiring external personnel also became important. At the end of 2015, the first part of the envisioned waste-

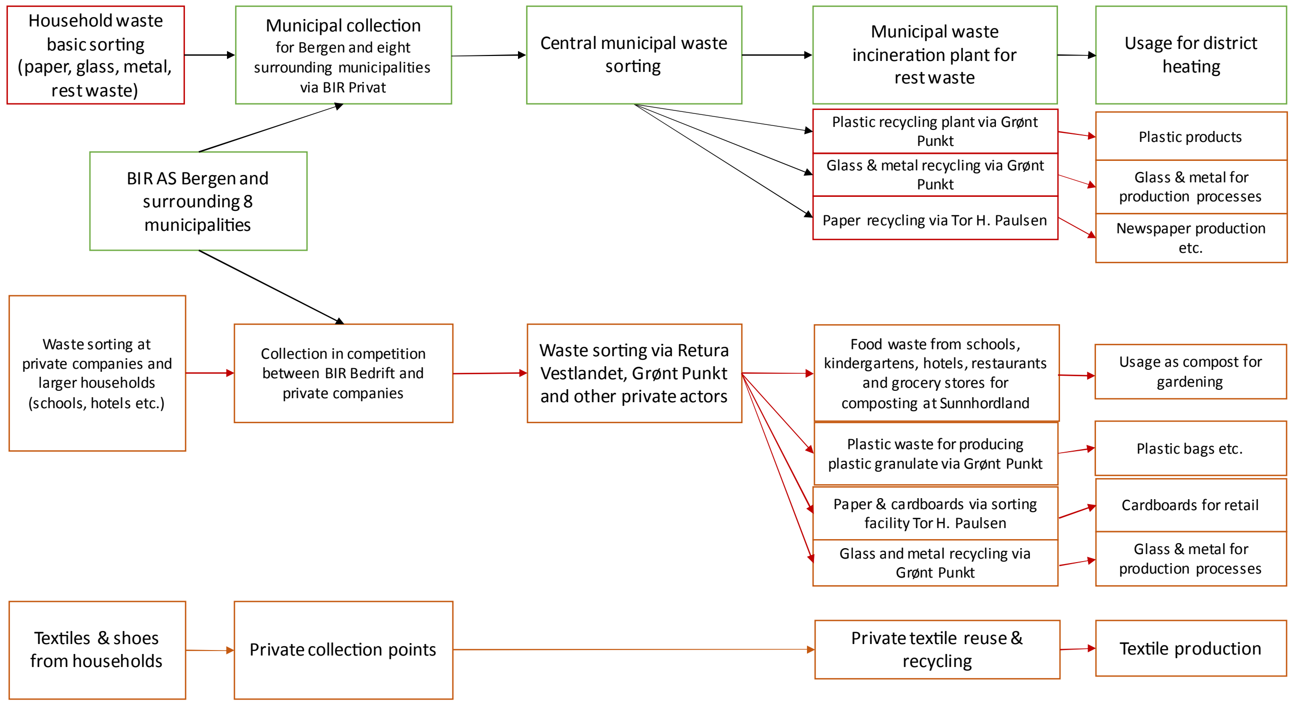

Fig. 6. The Bergen case: integration of municipal and private systems for organic waste management.

network could start operation, serving 4000 households. Since then the system has been under further development.

An interesting challenge for BIR is that for the processing of organic household waste, the biogas technology deployed in the eastern parts of Norway cannot be used. The main reason for this is that with the production of biogas also comes a bio-residual, an organic fertilizer that has to be ploughed back into the soil in order to improve grain production. However, in the region around Bergen (western Norway), there is limited agricultural land area and fewer farmers that need organic fertilizer. Moreover, transport of the bio-residual to eastern Norway is costly. Therefore, so far, BIR uses organic household waste for the production of energy in the incineration plant. The latest strategy of BIR for 2016–2020 explicitly states the goal that the better exploitation of food waste will be aimed for, and carbon capture and storage at the incineration plant is envisioned (BIR, 2016).

In response to this, and reflecting the important role of aquaculture along the Norwegian coast, BIR has established a cooperation effort with researchers in order to develop solutions for using food waste to produce fly larvae and to use them as a feedstock for aquaculture, replacing imported soya. This development is still at a very early stage, but the commercialization of this technology could be promising for many coastal regions in Norway (and beyond).

5. Analysis: governance for system optimization and system change in urban waste

The dynamics observed in the three city regions studied illustrate that there are multiple ways of governing and arranging for an effective, innovative and sustainable urban waste system. Addressing the research question at the outset of the paper – *How do different public governance regimes affect the dynamics across system optimization and system change in urban waste?*– we will now discuss how the three governance regimes condition system optimization and system change in the three regions. In order to ensure an integrated discussion and understanding of the respective city regions, the four dimensions of system optimization (i.e. infrastructure, institutions, networks and capabilities) will be included where relevant within the sub-sections on directionality, demand, coordination and reflexivity.

5.1. Directionality for system change in urban waste

The three cases have shown that a transition agent can take many forms. In Oslo, the public agency EGE in the municipality of Oslo has served as the main driver and coordinator for developing and implementing the circular system of processing and recycling the different streams of household waste. The circular waste recycling system was the rationale for building a waste sorting plant, the biogas facility and the waste incineration and district heating system. This can be seen as having ensured a system shift from energy recovery to recycling since the early 2000s. Still, after having arrived at the current recycling system, which is underpinned by heavy investment in *infrastructure* and *institutions* (e.g., the biogas plant, the sorting plant, the collection of household waste, and the routines of sorting waste in the households), there are few signals that the municipality is taking the lead on a new waste prevention system.

In Bergen, the municipality also set out the goals for system change in terms of the landfill ban in the mid-1990s, leading to increased incineration used for district heating. Subsequently, it sought to redirect, strengthen and establish close dialogue with BIR to accomplish the ambitious BossNett project from 2008. The BossNett solution itself was a direct result of the challenging physical *infrastructure* of the old city centre of Bergen. For both Oslo and Bergen, this way of setting ambitious societal goals constitutes a typical bureaucratic role.

This pattern differs somewhat from the Drammen case, where the inter-municipal collaboration has outsourced the commissioning of waste services to RfD, which seeks to live up to the orders from its inter-municipal owners and subsequently commissions various specific public tasks to private contractors. Drammen has, in this sense, applied a governance model, which is less in line with traditional bureaucracy and more in line with an NPM rationale. This implies giving priority to increasing efficiency, but at the same time, there is a limited ability to set the direction for system change. However, the publicly owned enterprise Lindum has played an important networking and entrepreneurial role in exploiting cross-sectoral and cross-regional inputs and outputs from across both public and private sectors. Lindum's legal status enables the treatment of waste from both the public and private sectors, as well as from other municipalities. This allows Lindum to develop a broader and more flexible system for urban waste management, spanning more sectors, than in the case of EGE in the municipality of Oslo. As such, governance in the Drammen case can be understood as expressing characteristics from both new public management and networked governance.

5.2. Demand for system change in urban waste

In the Oslo case, the recycling system involves using biogas from household waste on the city buses, which has ensured demand for biogas. Moreover, the bio-residual from the biogas plant was upgraded to bio-fertilizer to be used by the farmers in the Oslo city region. However, the farmers were initially sceptical about the new product because of their need to ensure that their crops and agricultural products lived up to standards of food security and health risk avoidance. These standards are part of the institutional set-up to protect and optimize traditional agricultural production (i.e. system optimization logic). The municipality therefore had to convince the local farmers surrounding the biogas plant at Romerike that the bio-fertilizer was a high quality product. In consequence, the biogas plant initially paid the local farmers to test the fertilizer. After a successful trial period, the plant now sells the same product to the farmers. This exemplifies how the public sector may pave the way for system change (Weber and Rohracher, 2012; Mazzucato, 2013, 2015, 2017). Within the terminology of system change, this example can be interpreted as showing the conflicting interests between system optimization and system change: that is, how the creation of the new circular organic waste system (system change) threatens the quality of the products in the existing system of agricultural production (system optimization). What this tells us is that the actors, institutions and practices underpinning the optimization of one system can be a barrier to the quest for system change. In this case, the municipality took on the burden of overcoming this barrier by convincing the farmers about the quality of the products to be sold, thus changing the institutionalized routines of the previous waste system.

One may argue that the capacity and demand for waste shown in the Oslo case constitutes a system that is oriented towards developing new value chains stemming from urban (organic) waste, and where the transition agent (EGE) has made heavy investments into the physical infrastructure enabling this production. At the same time, EGE has no financial incentives or political mandate to reduce the amount of waste in the first place. Such a sustainability mode, oriented towards recycling, is thus in conflict with demands for more circular eco-design aimed at limiting or preventing waste. In consequence, other types of actors – such as civic organizations (e.g. the student association) or private enterprises (e.g. Matsentralen) – are now the ones pushing the waste prevention agenda forward as the next stage of system change in urban waste.

In Bergen we have seen how the municipality steered the publicly owned governance agency in a more innovative and sustainable direction. The *network* of municipalities joining forces to establish the publicly owned enterprise BIR, and subsequently the creation of the new bridging position between the municipality and BIR, can be viewed as building the institutions for a new waste system. Nonetheless, the strengthening of the *coordination capabilities* of BIR by ensuring the relevant skills and people were involved also constitutes a central part of the ability to cause the *demand for system change*.

Then, in the Drammen case – quite the opposite from Oslo – Lindum aspires to change its business model from being based on selling new products stemming from waste to providing operational services for cutting-edge waste processing facilities and developing (in cooperation with other actors) and selling technology systems and sustainable solutions to both private actors and households. Such a dynamic and innovative demand factor appears more likely to move up in the waste hierarchy than a model in which heavy investments are made into physical infrastructures.

The three cases have also assigned different roles to the inhabitants of the three city regions as consumers. In Oslo and Bergen, the inhabitants are primarily involved in the waste system through their roles as producers of waste, which is delivered or collected from their household bins weekly. In the EU project Food2Waste2Food, in which Lindum is a partner, the inhabitants are allowed a potentially larger role as both the producers of organic waste and also as the potential consumers of the bio-fertilizer stemming from the processing of the urban organic waste collected. Knowing that involvement may cause greater understanding, motivation and dedication, such involvement of the inhabitants into the entire waste processing cycle may be a viable way to ensure greater interest in living sustainable lives.

5.3. Coordination for system change in urban waste

Owing to its corporate legal structure, EGE in Oslo cannot easily buy or process waste from the private sector and is instead restricted to processing household waste from the municipality of Oslo. At the same time, the public biogas plant at Nes in Romerike runs below capacity, and only 40% of the organic household waste is treated there. Currently, the municipality has no responsibility for food waste from private businesses. This restriction makes it difficult to reduce the operating costs of the biogas plant. However, ongoing experiments with adding manure as an additional feedstock will improve the cost efficiency of the Nes biogas plant.

In parallel to the public waste collection and processing system in Oslo, the private sector has developed its own system for waste management. Some of the larger organizations in Oslo, such as NorgesGruppen/ASKO, have built up internal waste management capabilities, while other companies rely on external providers, such as Ragn Sells. This lack of coordination across a parallel public and private subsector in the processing and treatment of organic waste in Oslo represents a suboptimal exploitation of the public infrastructure for waste processing, and limits potential critical mass and synergies across the sectors. Such a lack of coordination across the public and private sectors is an acknowledged weakness of a bureaucratic governance regime. Moreover, we have seen how the silo organization within the municipality represents fragmented incentives structures and thus a potential barrier to system change.

The waste processing system in Bergen represents better coordination across the public and private sector through the division of BIR into two departments serving the public and private sectors respectively. Moreover, in Bergen, the bridging position and function across the municipality and the publicly owned enterprise BIR has ensured better coordination and directionality for system change on the one hand, and more efficient system optimization on the other.

In contrast with the above model, Lindum in Drammen is a publicly owned enterprise, which is therefore able to buy and process waste from both the private and public sectors, including from other municipalities. Lindum has also engaged in operating some of the advanced biogas facilities in southern Norway, and can thus develop its capabilities and collaboration network. In this sense, Lindum constitutes a more flexible model of waste processing, allowing a greater action space for coordination and intersectoral orchestration due to a greater diversity of possibilities in terms of its waste resource base and potential end products and customers. Such an enabling of recombinant innovation across sectors and domains implies a more robust and less vulnerable model of creating more sustainable models of waste treatment. This observed form of (a networked governance mode) recombinant innovation across waste streams and sectors has at the same time experienced a mismatch with the silo-organization style of (traditional bureaucracy mode) national support schemes. Also, individual entrepreneurship seems to have been a key factor in the case of Lindum and Drammen, which implies that the observed dynamics will not necessarily take place in other contexts with the same governance set-up.

5.4. Reflexivity for system change in urban waste

A natural consequence of the fragmented relation across the public and private sector in Oslo is limited joint reflexivity and learning across the two domains. The tendering practices associated with a new public management regime in all the cases also entail clear boundaries between the commissioner and the contractor, which may serve to hinder dialogue and mutual learning.

In Bergen, joint reflexivity in the development towards more sustainable urban waste management is ensured by linking the contractor to the municipality through a specifically assigned bridging function. The close dialogue between the municipality and BIR stimulated BIR to aim to develop the circular system of upgrading organic waste to fodder for salmon, tailored to the fisheries tradition of the western coast of Norway. However, as in Drammen, here too the role of individuals may be significant, and setting up such a system elsewhere might not yield the same outcome.

In Drammen, the inter-municipal collaboration is likely to lead to a more professional agent with more resources, including knowledge development and reflexivity. At the same time, the tendering practices of RfD may represent a potentially rigid system in terms of lacking dialogue and feedback loops from the continuous waste processing system back to the policy level, which may hamper system change. Also, such new public management style tendering practices may represent weak possibilities for system change due to contract periods of six years plus two additional years, which might also represent static contract boundaries for system optimization. In principle, there is a possibility to include optional changes to the contracts, but we have not seen whether these are often in use. Formalized agreements and contracts stating what services are to be delivered will, in any case, tend to be an incentive to follow the contract and represent a similar disincentive to redefine the system and the services in the contract within the contract period.

Although Norway has a national interest organization working with waste policy issues (Avfall Norge), there is no governmental policy programme representing a coordination mechanism for joint reflexivity, learning and diffusion across municipalities in the case of waste. In consequence, there is a lack of coherence in waste systems and legislation in different municipalities, and there are several ongoing innovative projects that aim to transform existing municipal waste processing systems that unfold independently of each other. Such a lack of a coordinating mechanism for experience sharing and mutual learning may increase the costs and limit the effects of the ongoing initiatives.

5.5. Coexistence and interaction of governance regimes

Table 3 sums up the different governance regimes and innovation dynamics observed in the three cases. The Oslo case exemplifies balancing between different governance regimes through a mix of traditional bureaucracy and new public management. The internal setting of the direction in collaboration with the political level and EGE, and the creation of a circular system of bio-fertilizer and biogas to be used in the Oslo region, signals a traditional bureaucracy-type governance regime. EGE's ownership of the infrastructure and facilities also reflects a bureaucratic governance regime, which may constitute a barrier to other ways of processing the waste streams. At the same time, the tendering regime in the municipality, of outsourcing the municipal service provision of collecting waste and transportation services, constitutes an example of an NPM type of urban waste governance. Relatively standardized services such as waste collection and transporting are outsourced to private contractors, whereas the development and planning of the processing of the waste streams is accomplished in-house in the municipality. Importantly, the two styles co-exist in the same city region. In Oslo, traditional bureaucracy logic executes power and set political goals, which serves to give direction for system change. At the same time, the study showed how legal regulations that restrict public actors from processing waste from the private sector and vice versa may constitute a somewhat rigid institutional framework and limited incentives and action space for innovation. Moreover, the NPM-style outsourcing of the services of the collection and transportation of waste has led to two bankruptcies in the last few years and, subsequently, great difficulties in maintaining the public waste processing services. A stronger emphasis on traditional bureaucracy, in terms of a weaker weighting of price in the public tenders, and a closer control and dialogue with the private contractors, would probably have avoided the bankruptcies.

In Bergen, we have seen a similar kind of relationship between innovative roles to that in Oslo, although organized somewhat differently. The political level involved setting the direction for the new waste regime, in terms of stating the goals of waste-net (BossNett), and instructing and empowering the publicly owned enterprise BIR. Moreover, the establishment of the project organization to ensure the introduction and setting up of the new waste management system also constituted an important contribution to system change by the municipality. BIR was initially very much oriented towards cost efficiency within certain boundaries, but due to extensive and continuous pressure from the municipality of Bergen, it eventually undertook more innovative roles with more ambition, such as aiming to create the circular system of feeding insect larvae with organic waste in order to use the larvae as protein-rich fodder for salmon and chicken. In Bergen, the staffing of BIR and the close monitoring and coordination between traditional bureaucracy and NPM governance modes enabled this publicly owned enterprise to take the lead in system change.

In both Oslo and Bergen, the municipalities have taken the lead and set the direction for system change. At the same time, both Oslo and Bergen practise the outsourcing of collection and transportation services to private contractors, which constitutes an NPM mode of governance. In this sense, the traditional bureaucracy's quest for system change is accompanied by an ambition to operate existing public services in a cost-effective way. In sum, one may say that both Oslo and Bergen can be interpreted as expressions of a mix of traditional bureaucracy and NPM, but with the difference that, in Bergen, the municipality has managed to bridge these modes by employing a person to ensure close dialogue and understanding across the political side, the municipality and the publicly owned enterprise in charge of public operations.

In Drammen, we have seen an NPM tendering system administrated by the public agency (RfD), which enables publicly owned companies to compete with private companies and to provide services with a competitive edge (Lindum) both to the region and to other parts of the country. A central factor for accomplishing this was the entrepreneurial role and networked mode of this publicly owned company. In that way, Lindum could transcend the more limited resource capabilities of the Drammen region and get access to different markets, resources, competencies and technologies. The flexible position of Lindum combined with an entrepreneurial spirit has proven to be an important characteristic of an innovation system that is more likely to deliver system change than its counterpart in Oslo, where heavy investments in infrastructure, reflecting a recycling waste system, do not constitute an incentive for introducing another more sustainable system that is higher in the waste hierarchy.

Although Bergen and Drammen have chosen a somewhat similar basic organization model for their urban waste service provision (i.e. organized as a publicly owned enterprise), the study has shown how the two city regions have had quite different development paths, which can probably be ascribed to context-specific factors such as the resources available, competences and personal motivation. The Drammen case shows how regulatory and ownership structures allowed the present entrepreneurial spirit of Lindum to unfold. In sum, despite being different, the three cases all represent similar innovative functions or roles related to balancing between optimizing service production within the existing boundaries on the one hand, and altering the very same systems of service provision on the other hand.

Table 3
Summing up the different governance regimes and innovation dynamics in the three cases.

City region	Governance regime	Transition agents	System optimization	System change
Oslo	Non-integrated hybrid of traditional bureaucracy & new public management: governance agency handles processing of waste at recycling stations and biorefinery. The municipality owns its own processing facilities and infrastructure. Use of private contractors on limited activities, and tendering regime on collection and transport of waste	Municipal agencies; Energigjenvinningsetaten (EGE) and Renovasjonsetaten	Primarily recycling mode in waste hierarchy. No incentives for business development beyond recycling in EGE, and no incentives for business development among private contractors beyond mandate in public tenders. Little coordination across public, civic and private sector; EGE prevented from processing organic waste from industry due to legislation. Arms-length distance between public and private sector due to regulation in tendering regime. As a consequence of the lack of coordination also a lack of joint reflexivity. The tendering practice also entails clear boundaries between commissioner and contractor, which may limit mutual learning	Directionality set by political goals in 2006 and accomplished by municipal agency. Politically driven demand. Has developed circular system regionally (biogas and biofertilizer) through innovative public demand policies
Bergen	Integrated hybrid of traditional bureaucracy & new public management: government agency in charge but assigning considerable power to publicly owned enterprise with business development unit serving the private market	Municipal agency and publicly owned enterprise (Bergen Kommune and BIR)	Publicly owned enterprise initially in charge of demand. Initial ambition non-successful due to poorly defined demand and organization. Municipal agency ensures that publicly owned enterprise possesses necessary competences and innovative ambitions	Directionality set by political goals in 2008 (BossNett) and accomplished by publicly owned enterprise with continuous and close dialogue and follow-up from municipal agency. Coordination across Bergen and 8 smaller neighbouring municipalities. Strong coordination by municipal staff serving a bridging role between government agency and publicly owned enterprise. Reflexivity and learning caused by an initial crisis in setting up waste-net and as an outcome from extensive and continuous coordination and dialogue across the government agency and the publicly owned enterprise
Drammen	Hybrid of new public management & networked governance: public agency commissioning waste services on behalf of 9 municipalities regionally. Contracts assigned to publicly owned enterprise and/or private companies	Municipal agency and publicly owned enterprise (RfD and Lindum AS)	Low frequency and high rigidity in demand caused by contract periods of 6 + 2 years in tendering practices. Contract practice represents silo organization; politically formulated mandate assigned to inter-municipal agency represents no incentives for collaboration with other agencies horizontally. Learning and reflexivity restricted by tendering practices and potentially limited by silo organization	Municipal owners setting the direction through political order to intermunicipal commissioning agency. Publicly owned private contractor benefits from diverse contact points across industry sectors and across public and private sector. Private contractor legally enabled to process organic waste from both private and public sector, which gives increased action space for innovation. Inter-municipal agency takes part in national industry arenas for dialogue and knowledge development. Strengthening of skills base and professionalism in intermunicipal commissioning agency

6. Conclusions: governance balancing system optimization and system change

In this paper we have seen how three city regions have set up and organized the provision of municipal waste services in different ways. We have also shown how the different urban waste systems have characteristics that can be interpreted as reflecting (combinations of) different governance regimes, and how these governance regimes have implications for various forms of innovation.

The paper has illustrated how the municipalities are subject to expectations of achieving balance between system optimization and system change. On the one hand, they need to ensure that established practices and services are conducted and accomplished in a cost-efficient and well-functioning way for the inhabitants. On the other hand, the municipalities are responsible for redesigning and arranging for more long-term leaps in terms of sustainable system change. These two functions of innovation can be seen as contrasting in the sense that they possess different objectives and rationales. At the same time, they can be seen as complementary, as they both fulfil different roles in the evolutionary innovation ecology.

With respect to governance regimes, the paper has shown how these possess different strengths and weaknesses in enabling system optimization and system change, depending upon how they co-exist in various forms and how they are applied. The cases have suggested that traditional bureaucracy is good at directionality, but that at the same time it may create lock-in. Moreover, NPM may be better at cost-efficiency and optimization within given system boundaries, but paradoxically it seems that such a regime needs to co-exist and be controlled by the bureaucracy in order to work best. NPM may also prevent lock-in from investments in physical infrastructure. Finally, networked governance ensures broad anchoring, avoids fragmentation and stimulates recombinant innovation. In sum, there is not one best governance regime, but a need to acknowledge their co-existence and carefully consider the characteristics of the different regimes in order to arrange for long-term dynamic and sustainable city regions.

All three city regions have arrived at more sustainable waste systems by going through system shifts upwards in the waste hierarchy. This illustrates that despite regional differences in governance regimes, all of them may cause transformational innovation or system change. Still, rather than having aimed for the most sustainable waste system in terms of waste prevention, the developments can be interpreted as a step-by-step move upwards in the waste pyramid towards more sustainable production and consumption systems. It seems as if the urban waste issue is perceived and understood as a challenge of system optimization rather than system change. The silo-based working practices, where each municipal department is responsible for its respective part of the value chain, reflects such an understanding.

Viewing this as a challenge requiring system change would probably have ensured a stronger degree of directionality and a broader anchoring of actors. Such an approach is likely to have arrived at a waste prevention mode more quickly than the step-by-step-solutions implemented so far. Instead of addressing urban waste systems in siloes, one should approach these through collaborative initiatives that span the entire value chain from the start. This calls for the exploration of new forms of working practice that transcend existing organizational boundaries and structures when addressing complex societal challenges. An empowered coordinating mechanism across municipalities – at regional or national level – would probably have ensured stronger directionality and improved joint reflexivity across the stakeholders involved.

Acknowledgements

This paper is part of the output from the research project SusValueWaste (2015-2019) led by the Nordic Institute for Studies in Innovation, Research and Education (NIFU). The project has been funded by the BIONÆR Research Programme in the Research Council of Norway on Sustainable Innovation in Food and Bio-based Industries. We would like to thank the three anonymous reviewers for their insightful and constructive comments and suggestions. We would also like to thank the editors for their guidance and thoughtful advice. The usual disclaimers apply.

References

Albury, D., 2005. Fostering innovation in public services. Publ. Money Manage. 25, 51–56.
Andersen, S.S., 1997. Case-studier og generalisering. Fagbokforlaget, Bergen.
Aucoin, P., 1990. Administrative reform in public management. Governance 3, 115–137.
BIR, 2016. Avfalls- og ressursstrategi 2016–2020, 55. BIR, Bergen.
Bulkeley, H., Gregson, N., 2009. Crossing the threshold: municipal waste policy and household waste generation. Environ. Plan. A 41, 929–945.
Davoudi, S., Evans, N., 2005. The challenge of governance in regional waste planning. Environ. Plan. C: Govern. Policy 23, 493–517.
Eggers, W.D., Kumar Singh, S., 2009. The Public Innovator's Playbook: Nurturing Bold Ideas in Government. Deloitte Research and Ash Institute for Democratic Governance and Innovation at Harvard Kennedy School of Government, Washington, DC.
Eisenhardt, K.M., 1989. Building theories from case study research. Acad. Manage. Rev. 14, 532–550.
European Parliament and Council of the European Union, 2008. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives (Waste Framework Directive). European Parliament and Council of the European Union, Brussels.
FAO, 2011. Global Food Losses and Food Waste: Extent, Causes and Prevention. Food and Agriculture Organization, Rome.
Frantzeskaki, N., Kabisch, N., 2016. Designing a knowledge co-production operating space for urban environmental governance. Environ. Sci. Policy 62, 90–98.
Frantzeskaki, N., Loorbach, D., 2010. Towards governing infrasystem transitions: reinforcing lock-in or facilitating change? Technol. Forecast. Soc. Change 77, 1292–1301.
Gee, S., Uyarra, E., 2013. A role for public procurement in system innovation. Technol. Anal. Strateg. Manage. 25, 1175–1188.
Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes. Res. Policy 31, 1257–1274.
Hartley, J., 2005. Innovation in governance and public services. Publ. Money Manage. 25, 27–34.
Hess, M., Adams, D., 2007. Innovation in public management: the role and function of community knowledge. Innov. J.: Publ. Sector Innov. J. 12.
Hodson, M., Marvin, S., 2010. Can cities shape socio-technical transitions and how would we know if they were? Res. Policy 39, 477–485.
Hood, C., 1991. A public management for all seasons? Publ. Adm. 69, 3–19.
Hoornweg, D., Bhada-Tata, P., Kennedy, C., 2013. Waste production must peak this century. Nature 502, 615–617.
Hovland, K.M., 2017. Søppelselskapets nedtur: Dette gikk galt for RenoNorden. pp. E24. https://e24.no/boers-og-finans/renonorden/soeppelselskapets-nedtur-dette-gikk-galt-for-renonorden/24144725.
Jonsson, D.K., 2000. Sustainable infrasystem synergies. J. Urban Technol. 7, 81–104.
Kemp, R., Schot, J., Hoogma, R., 1998. Regime shifts to sustainability through processes of niche formation. Technol. Anal. Strateg. Manage. 10, 175–198.
Kemp, R., Loorbach, D., Rotmans, J., 2007. Transition management as a model for managing processes of co-evolution towards sustainable development. Int. J. Sustain. Dev. World Ecol. 14, 78–91.
Klein Woolthuis, R., Lankhuizen, M., Gilsing, V., 2005. A system failure framework for innovation policy design. Technovation 25, 609–619.
Klima- og miljødepartementet, 2014. Nasjonal tverrsektoriell biogasstrategi. Klima- og miljødepartementet, Oslo.
Klima- og miljødepartementet, 2017a. Industry Agreement on Reduction of Food Waste. Klima- og miljødepartementet, Oslo.
Klima- og miljødepartementet, 2017b. Meld. St. 45 (2016–2017) Avfall som ressurs – avfallspolitikk og sirkulær økonomi. Klima- og miljødepartementet, Oslo.
Kuhlmann, S., Rip, A., 2014. The Challenge of Addressing Grand Challenges. University of Twente, Twente.
Lauridsen, E.H., Jørgensen, U., 2010. Sustainable transition of electronic products through waste policy. Res. Policy 39, 486–494.
Loorbach, D., 2010. Transition management for sustainable development. Governance: Int. J. Policy Adm. Inst. 23, 161–183.
Markard, J., Truffer, B., 2008. Technological innovation systems and the multi-level perspective: towards an integrated framework. Res. Policy 37, 596–615.
Mazzucato, M., 2013. The Entrepreneurial State: Debunking Public vs. Private Sector Myths. Anthem Press, London.
Mazzucato, M., 2015. The Green Entrepreneurial State. SPRU Working Paper Series 2015-28. SPRU Science Policy Research Unit. University of Sussex, Brighton.
Mazzucato, M., 2017. Mission-Oriented Innovation Policy: Challenges and Opportunities. UCL Institute for Innovation and Public Purpose, London.
Miljøverndepartementet, 2013. Fra avfall til ressurs: avfallsstrategi. Miljøverndepartementet, Oslo.
Moore, M., Hartley, J., 2008. Innovations in governance. Publ. Manage. Rev. 10, 3–20.
Mourad, M., 2016. Recycling, recovering and preventing "food waste". J. Cleaner Prod. 126, 461–477.

Murray, R., 2002. Zero Waste. Greenpeace Environmental Trust, London.
Osborne, S.P., 2006. The new public governance? Publ. Manage. Rev. 8, 377–387.
Parsons, W., 2005. Designing for innovation in the public sector. Administration 53, 7–18.
Schot, J., Steinmueller, W.E., 2018. Three frames for innovation policy: R&D, systems of innovation and transformative change. Res. Policy 47, 1554–1567.
Schubert, T., 2009. Empirical observations on new public management to increase efficiency in public research: Boon or bane? Res. Policy 38, 1225–1234.
Self, P., 1993. Government by the Market. Macmillan, Hong Kong.
Smith, A., 2007. Emerging in between: the multi-level governance of renewable energy in the English regions. Energy Policy 35, 6266–6280.
Sørensen, E., Torfing, J., 2011. Enhancing collaborative innovation in the public sector. Adm. Soc. 43, 842–868.
Uyarra, E., Gee, S., 2013. Transforming urban waste into sustainable material and energy usage. J. Cleaner Prod. 50, 101–110.
Weber, M., 1978 (1922). Economy and Society. University of California Press, Berkeley, CA.
Weber, K.M., Rohracher, H., 2012. Legitimizing research, technology and innovation policies for transformative change. Res. Policy 41, 1037–1047.