A SYSTEMS ANALYSIS METHODOLOGY FOR EXPLORING URBAN SUSTAINABILITY TRANSITIONS

Exploring challenges and opportunities for urban sustainability transitions in Ghent and Aberdeen

Suzanne Maas[1], Karen Fortuin[1], Niki Frantzeskaki[2] & Chris Roorda[2]

1. Environmental Systems Analysis Group, Wageningen University and Research Centre (WUR), Wageningen, the Netherlands.
2. Dutch Research Institute for Transitions (DRIFT), Rotterdam, the Netherlands.

1. Introduction

Cities worldwide increasingly face challenges such as climate change pressures, demographic changes and resource scarcities. To deal with increasing energy demands, energy dependencies and risks of energy poverty due to unstable energy prices, cities investigate ways to transition to low carbon futures. At a transnational level, the European Union (EU) has enforced the climate and energy strategy with *20-20-20 targets* that set the ambitions for 20% CO_2 emission reduction, 20% of energy consumption from renewable sources, and a 20% reduction in energy use by 2020 (European Commission, 2010). Many European cities have already committed themselves to reductions that go beyond these EU targets, for example through the Covenant of Mayors: a commitment between mayors of cities in EU countries to increase local sustainable energy production and consumption and reduce CO_2 emissions beyond the targets set by the EU (Covenant of Mayors, 2011). Achieving these targets and realizing the necessary changes is difficult due to the complexity of these issues. A transition to a low carbon city requires a wide variety of actions (Swart and Raes, 2007), because climate change has multiple causes and consequences and involves a wide range of societal domains, actors and scale levels (Loorbach, 2009). Cities and their governments have to deal with these challenges, implement climate and energy policy and take leadership for their geographic area and hinterland (Newman and Jennings, 2008).

Common barriers that prevent cities to deal with these challenges include: (i) policy fragmentation, referring to the phenomenon that local energy strategies are often developed in isolation from other policy domains such as spatial planning or mobility leading to inconsistent and incompliant strategies and policy plans; (ii) lacking or discontinuous political commitment due to political cycles and due to uncertain benefits from proposed actions; related to this, (iii) a myopic focus on sort-term goals and gains, instead of long-term sustainability goals; and (iv) the fact that the local government is just one of the actors in a city with (often) limited impact on the energy sector and market. A local government cannot induce change alone; complex problems require mobilisation of a broad range of actors (Roorda et al., 2011).

An approach to bring together multiple actors to form a strategic agenda for sustainability transitions is Transition Management (Loorbach 2010; Frantzeskaki et al 2012). Transitions are radical changes, or "structural changes in our societal systems" that go beyond small changes within the dominant culture, structure and practices of a societal system (Loorbach, 2007). Transition management is characterized by long-term integrative thinking, involving multiple actors, and a focus on learning and system innovation next to system improvement (Rotmans et al., 2001). Transition management as a governance process approach can be applied and tailored to the urban context to guide different cities through the process of understanding the problems they face, formulating a vision for the future, searching for strategic actions and forming an agenda for change (for more information see: Loorbach, 2007; Rotmans and Loorbach, 2009). An application of transition management in the urban context with a focus on energy system is realised within the FP7 funded project MUSIC (Mitigation in Urban areas and Solutions for Innovative Cities). MUSIC is a transnational project aimed at reducing CO_2 emissions and energy use in five North-Western European cities. It applies transition management to stimulate climate mitigation in urban areas in order to reach targets ranging from 50% CO_2 reduction by 2030 (MUSIC, 2011) to climate neutrality in 2050 (Balthazar, 2008). The project addresses an issue that local governments all over North-Western Europe struggle with: 'how to get from policy goals on CO_2 targets to reductions in practice?'

This paper deals with a systems analysis methodology that was developed for the first phase of the transition management process in cities participating in the MUSIC project. It was expected that a systems analysis methodology could have a twofold contribution to the transition management process. Firstly, a systems analysis methodology can provide an overview of the system, in this case the city's status, characteristics and networks that are relevant from a sustainability perspective, integrating social, environmental and economic domains. This information is crucial for later phases of the transition management. Secondly, conducting a systems analysis can stimulate holistic thinking and provide a common ground among people participating in the analysis (Miser and Quade, 1985; Rotmans and Loorbach, 2009). A systems analysis can create a shared language and common understanding of the problems and challenges in the city among project participants. As such the systems analysis is expected to create a common information base to start the negotiation and reflection by engaging people from different backgrounds, such as from the local government, business, science and civil society. The overall objectives of the system analysis methodology in this context are to enable the cities to identify key challenges and new opportunities with respect to energy and CO_2 reductions, and to initiate a dialogue between policy actors, scientists and community members.

Below we present the systems analysis methodology that was designed and applied in the MUSIC project as well as a reflection on the application of this methodology in two European cities: Ghent (Belgium) and Aberdeen (United Kingdom). More specifically, we address the following research questions:

What are the characteristics of the systems analysis methodology applied in Ghent and Aberdeen as part of a transition management process?

What does the systems analysis methodology offer for unravelling sustainability challenges and for the identification of opportunities for change in European cities that face the challenge of reducing energy and CO_2 emissions?

We developed a systems analysis methodology fitting within the transition process applied in the MUSIC project based on existing systems analysis methods and tools, which we identified through literature review. As such the system analysis methodology that we developed has a modular configuration: it consists of adapted tools and techniques that in a step-wise application unravel challenges and opportunities for urban sustainability transitions.

In section 2 we elaborate on the objectives of performing a systems analysis and an elaboration of the systems analysis methodology. The third and last author have been involved as city coaches in Aberdeen and Ghent respectively, assisting and consulting the *transition team* – the team that organises and facilitates the transition process – on applying the systems analysis methodology and the wider transition process. The first author was involved in the development of the systems analysis methodology and its application in Ghent. The context, outcomes and application of the systems analysis methodology in Ghent and Aberdeen are presented in section 3. In order to gain information about the application and outcome of the systems analysis methodology the first, third and last author participated and helped with analysing the data gathered for the systems analysis. The results from reflection on the content and process goals in the two case studies by the different parties are presented in the discussion in section 4. The city coaches and the developer of the methodology reflected on the application and outcomes of the systems analysis methodology, and the first and last author interviewed three members of the transition team of Ghent to learn more about the experience of the transition team members. These transition team members and 12 transition arena participants – frontrunners that participated in a series of so-called arena workshops about the transition challenge in their respective city – in Ghent were asked to reflect upon the methodology by filling in a questionnaire which inquired about their experience. In section 5, we present our conclusions.

2. Systems analysis methodology

2.1 Introduction

Systems analysis can be used to provide an overview of the system, to produce a baseline assessment of the system's state, to demarcate system boundaries, and to separate symptoms from problems (Findeisen and Quade, 1985; Miser and Quade, 1985; Rotmans and Loorbach, 2009). An essential output of a systems analysis is a systematic and consistent analysis of the variables and elements that constitute its whole (Pahl-Wostl 2007, Saravanan 2008, p.203). One of the important outcomes of the systems analysis methodology that we present below is that it should provide an integrated overview of the system with factual information as well as an understanding of the problems from different perspectives, from the viewpoint of different actors. This overview is needed to address the challenges related to energy and CO_2 emission reduction goals that cities face. It facilitates the identification of areas that require change as well as possible courses of action needed to meet these goals.

More specifically the systems analysis methodology should provide (i) *an overview of the system and a detailed systematic analysis of its state and characteristics*. In this overview the properties and elements of the system as well as the links and interdependencies between them should be identified (Saravanan 2008, p.214); (ii) *an analysis of the history of the system including historical evolution pathways and events*. The timelines of elements and properties of the system can be used to provide a view of its historical development, explain historical path-dependencies, and create historical parallels (Rotmans and Loorbach, 2009); (iii) *a problem identification and formulation from a system's perspective*. By analysing the system and its properties, problems can be revealed. The understanding of the interdependencies of system's elements provides an understanding of what the problem is, and gives insight into causes and symptoms (Rotmans and Loorbach, 2009).

Next to providing an overview of the system under study, a systems analysis also includes the perspectives and knowledge of those who are involved in the analysis. This is very important for the first phase of transition management, because it enables people from different (scientific) backgrounds to work together, and to combine objective data with subjective perspectives.

Therefore, the systems analysis methodology that we present below, should also meet the following objectives: (i) *stimulate holistic thinking among its participants*. Analysing the system in an integrative and holistic manner provides an information-rich and comprehensive base for negotiations and learning. Conducting a systems analysis in cooperation with experts and policy actors might stimulate holistic thinking about the system and the problem (Rotmans and Loorbach, 2009); (ii) *provide a common information base and shared understanding.* Undertaking an integrated analysis of a system enables participants to create a common ground and a common perception of the system (Banathy, 1988; Jansen, 2009); (iii) *pinpoint areas and actors of the system contributing to problems of unsustainability and in turn to create a sense of urgency for action.* The presentation of persistent problems, showing the unsustainability of the current system, gives rise to a sense of urgency and justifies the need for change (Rotmans and Loorbach, 2009; Saravanan, 2008, p.214).

The systems analysis methodology that we present below combines the provision of an integrated overview of the system with a process of inquiry that supports a holistic, participative approach to problem analysis, and forms the first step towards finding solutions.

2.2 Application of the methodology

The basic structure of the systems analysis methodology we propose is built up according to four steps: 1) system definition, 2) system structuring, 3) data gathering and 4) data assessment and analysis (see Figure 1).

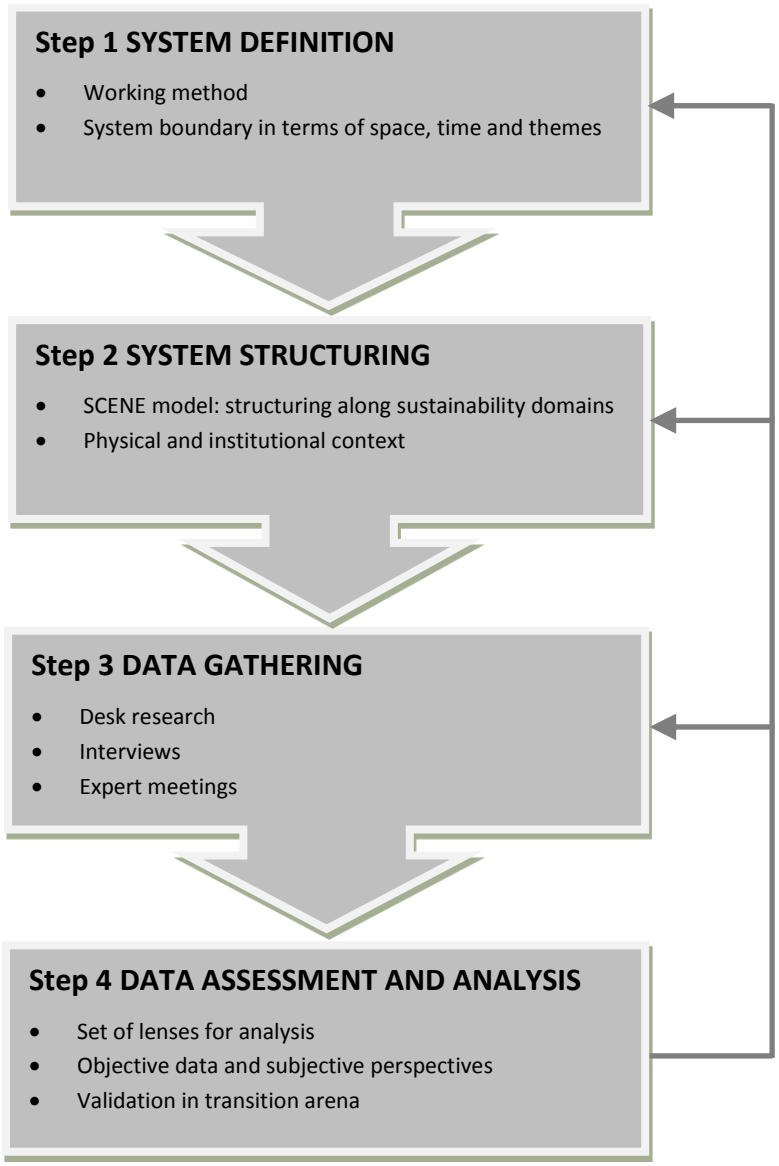

Figure 1 *Overview of the systems analysis methodology*

Step 1: System definition

The first step in the systems analysis is to determine the role of the systems analysis within the wider transition process. Decisions need to be made on the working method, communication structure and project management. Thereafter, the system under study needs to be defined; the boundaries of the system have to be set in order to clarify the unit of analysis. In principle, there are no general inclusion or exclusion rules, so what is included depends on the problem the analyst(s) wants to address (van der Brugge, 2009). The systems' boundaries can be defined in terms of space (the physical boundaries), in time (how far to look back, how far ahead) and themes (the focus of the study and the understanding of relevant in- and outputs). The transition team decides on the system definition but, as the systems analysis is an iterative process, this can be challenged and further discussed in the subsequent steps of the systems analysis (see step 2, 3 and 4). Decisions on setting boundaries in space, time and themes are inspired by the reason to start the transition process, but require careful thought and discussion, in order to grasp the implications of different choices. In the case of a municipality with a policy plan, there are already some guidelines to steer the process. For example, the border of a municipality forms a natural boundary in terms of space, and the end term of a policy goal (e.g. climate neutral in 2050) forms a natural boundary in terms of space.

Step 2: System structuring

The second step in the systems analysis is structuring the system, in order to be able to make an abstraction of the complex system. Such an abstraction is useful as a framework within which the system can be examined and discussed. In this systems analysis methodology, the SCENE model is used as a framework. SCENE is a model based on the sustainability triangle, consisting of three capital domains: SoCial, ENvironmental and Economic (Rotmans, 1998). SCENE extends the traditional sustainability triangle, that solely portrays the interconnectedness between the three domains, with capital stocks that represent properties of the system and flows that define the relationships between them. Stocks can be quite generic terms, such as 'quality of life', 'environmental quality', or 'economic vitality' (Grosskurth, 2008), but also more specific, such as 'education' or 'mobility'. Flows are aspects that change relatively quickly in the short-term and reveal the relationship between stocks (Rotmans et al., 2001). Depending on the required level of detail the SCENE model with stocks and flows can be further specified to include characteristics and indicators. Because of the important role of the physical and institutional context in an urban environment, the stocks in the social, environmental and economic domains are placed within wider circles representing the physical and institutional context. Within the transition team, important stocks in the context of the specific city are defined, with the aim of coming to a good mix between the three sustainability domains. This can be done through discussions, but also more visually by means of placing sticky notes on the different sustainability domains. The flows between the stocks, as well as relevant physical and institutional factors, are also identified and described. The outcome of this step is an empty framework that will guide the transition team in the data gathering step.

Step 3: Data gathering

The third step in the systems analysis is gathering data. The systems analysis is conducted in an iterative, participative, trans-disciplinary way. Members of the transition team gather data for the systems analysis using a combination of desk research, interviews and expert meetings, to ensure input from different disciplines and perspectives. The systems analysis is done in an iterative manner: information from different sources is used to reconsider the findings from another source, so as to validate the results. Desk research is used to collect data and statistics of the city (e.g. demographic data, income distribution, historical data, spatial data and environmental data) and review and assess existing strategies, visions and white papers that the city has formulated on the themes of the systems analysis. Data and statistics collection and the reviewing of existing policy documents are important for the systems analysis since they will bring to the foreground which information is available and how this information has been interpreted and used by e.g. policy makers. Interviews and expert meetings are used to complement the findings of the desk research with the perspectives of different actors and experts and get a broader picture of what the properties of the systems are, how these are interconnected and which problems arise.

Step 4: Data assessment and analysis

The fourth step of the systems analysis entails data assessment and analysis. A set of lenses are presented that together reflect the variety of ways of looking at the system. The different lenses are structured according to the multi-level model (the landscape-regime-niche levels, or macro-meso-micro levels; Schot and Geels 2007) and together ensure an integrated perspective and analysis of the system (see Table 1). The lenses are primarily used by the transition team, fed by information obtained from desk research, interviews and expert meetings. The systems analysis, including the presentation of the results of these different lenses, is presented in the first *transition arena*: a workshop involving frontrunners from different backgrounds. However, the systems analysis is not finished yet: the participants of the arena can include their input and perspectives by means of discussion and feedback, in order to adapt the systems analysis where necessary, create a 'common frame of reference', and ultimately validate the systems analysis.

Table 1 *Systems analysis: lenses*

Level	Lenses	Explanation
Macro	Landscape influences	A description of current landscape influences. From a system-environment view influences that occur outside, yet influence the system (such as global economic trends) are described.
	Historical sketch	A description of historical change over a long time period (>100 years). Historical developments are described to unravel the characteristics of a city and draw historical parallels.
Meso	State of the system	The SCENE model is completed, i.e. the stocks, flows and/or characteristics are identified and named, to get an overview of the properties of the system. Major influences from the physical and institutional context specific for the city are also described. An optional application is to assess the baseline of the system, to use for benchmarking.
	Relations between stocks	An investigation and description of the relationships and interdependencies between stocks. This description can lead to the identification of important stocks and insight in feedback mechanisms.
	Selection of main assets	Narrowing down of stocks to the most important assets for the city, to use for characterising the city, structuring the problem and further on in the envisioning process.
	Trend analysis	A description of trends in stocks or main themes over the past 50 years, to identify capital losses or gains, turning points and possible path dependencies.
	Dominant culture, structure and practices	Identification and description of the dominant structures, culture and practices in the city. Identification of these characteristics of the workings of the current regime is part of the problem structuring process.
Micro	Identification of niches	A description of niche developments within the main themes give an indication of what is happening outside of the regime and can be used as examples in the envisioning process.

3. Case studies

The systems analysis methodology was applied in the cities of Ghent and Aberdeen as the first step of the transition management approach in the MUSIC project. The aim was to identify the challenges and opportunities in their cities with respect to energy and CO_2 reductions as part of the first phase of transition management, the preparation and exploration phase. The cities adapted the analysis to their local circumstances. The outcomes of the systems analysis served as input for the second phase of the transition management strategy: the development of a joint vision and a transition agenda.

In both Ghent and Aberdeen, the initiative for taking action on the energy and climate goals of their municipality, and participating in the MUSIC project, came from within the local authority. Therefore, the transition team was made up of policy officers from the municipality, together with experts in participatory process management and transition management, as well as a city coach -the transition expert from DRIFT- who assisted the transition team. The transition team of Aberdeen consisted of a policy officer from the environment department of the municipality of Aberdeen, two policy officers with expertise on energy and community engagement from the environment department of the municipality and the city coach – the third author of this paper. The transition team of Ghent consisted of two policy officers from the environment department of the municipality of Ghent, a transition expert and a process facilitator – responsible for project management – and the city coach – the fourth author of this paper. The transition team was assisted by the developer of the methodology – the first author of this paper (see Figure 2).

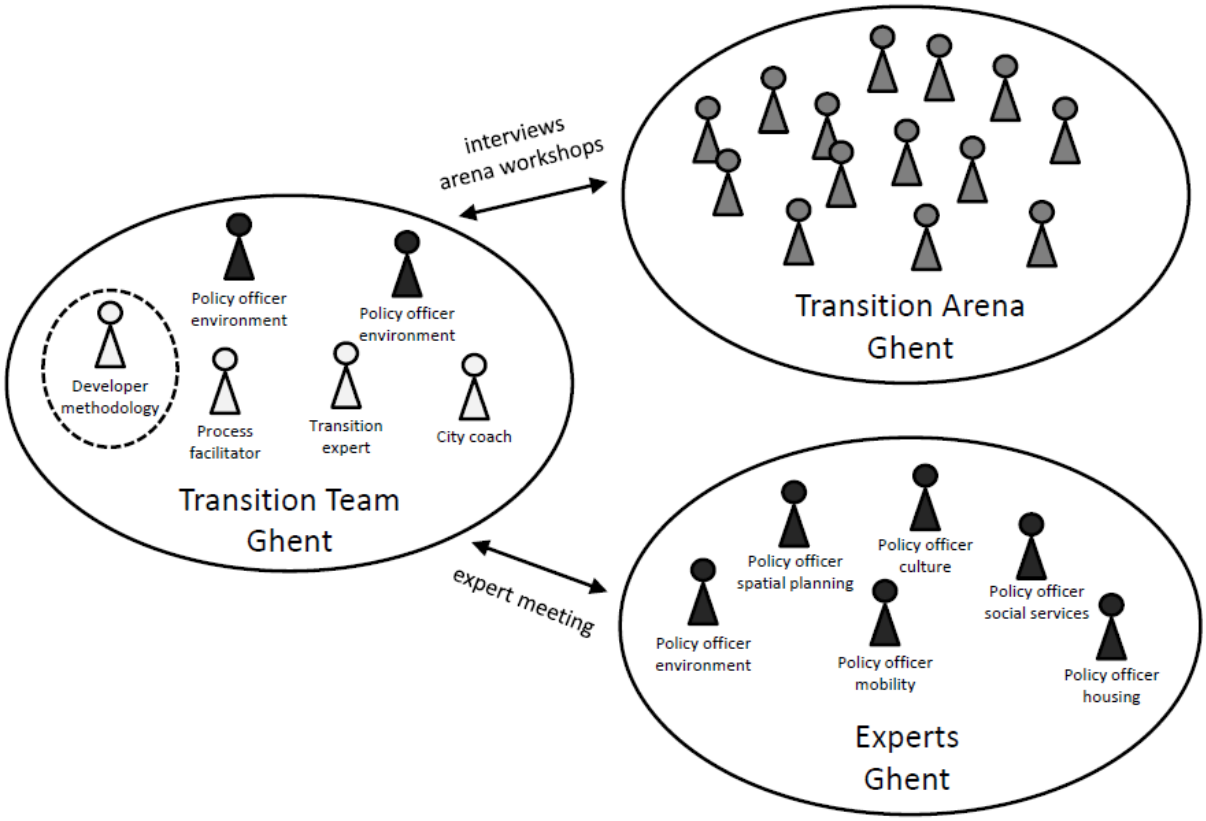

Figure 2 *Participants in the transition process in Ghent*

Figure 2 shows the actors in the transition process, who belong to three groups: the transition team, the transition arena and a group of experts. Black figures represent policy officers from within the municipality. Grey figures represent individuals who work and/or live in Ghent and have been selected on the basis of their innovative way of thinking; the frontrunners. The white figures represent the external professionals who assisted in the process by means of project management, consultation and coaching.

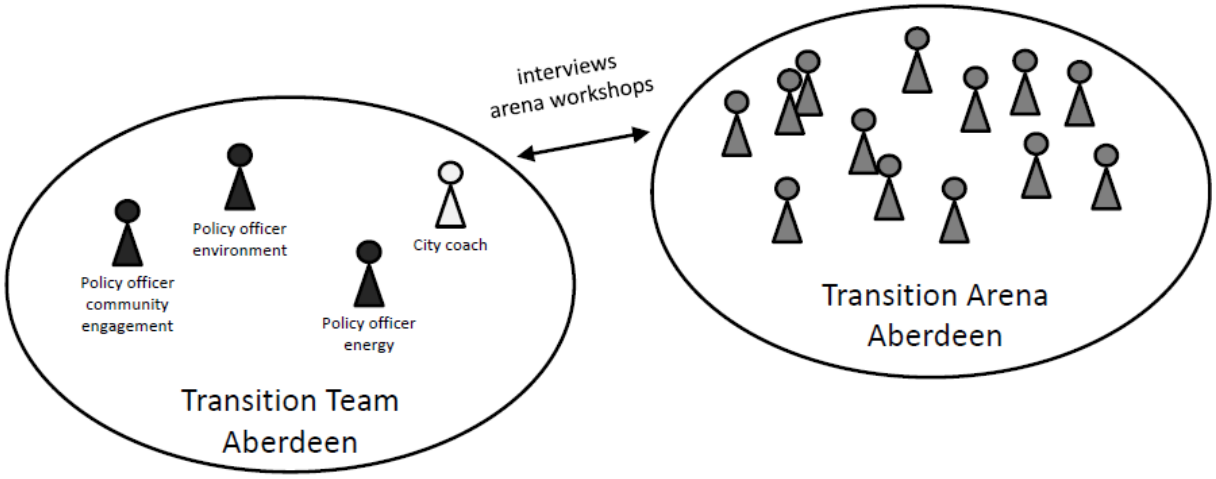

Figure 3 *Participants in the transition process in Aberdeen*

Figure 3 shows the actors in the transition process, who belong to two groups: the transition team and the transition arena. Black figures represent policy officers from within the municipality. Grey figures represent individuals who work and/or live in Aberdeen and have been selected on the basis of their innovative way of thinking; the frontrunners. The white figure represents the external professional who assisted in the process by means of project management, consultation and coaching.

The systems analysis was performed in an iterative manner, together with experts and frontrunners (see Figure 2 and 3), by means of a combination of desk research, interviews, expert meetings and the transition arena workshops (see Table 2 and 3). In both cities the system analysis methodology was meant to unravel the complexity of the city and to shift the municipality's focus on initial solutions to systemic challenges and opportunities.

As Ghent, of all cities participating in the MUSIC project, was furthest ahead in the process and had a tightly planned schedule for the different steps of the transition process, the systems analysis methodology was developed during the implementation of the systems analysis in Ghent, leading to an iterative cycle of development, implementation, results and evaluation in order to improve the methodology along the way. This means the systems analysis was very much tailored to the specific needs in the municipality of Ghent and was developed together with the people who would be using and applying the methodology.

Table 2 *Application of the systems analysis steps in Ghent*

Step	Application in Ghent
1 System definition	*January – February 2011*: System definition based upon discussions in transition team meetings and first data gathering from policy documents.
2 System structuring	*January – February 2011*: Analysis of existing policy documents of the municipality by the policy officers in the transition team. *March 2011*: Discussion and sticky notes exercises to place stocks in domains by members of the transition team. *5 April 2011*: Discussion and sticky notes exercises to place stocks in domains in expert meeting with policy officers from other departments within the municipality, in dialogue with the transition team.
3 Data gathering	*January – April 2011:* Reviewing and analysing information from reports, statistics, newspaper clippings, websites, interviews and SWOT analyses by policy officers from the transition team. *March – April 2011*: Interviews by policy officers from the transition team with 14 frontrunners, who were thereafter invited to participate in the transition arena sessions.
4 Data assessment and analysis	*March – May 2011:* Discussion in transition team and working together to structure data according to the different lenses. *5 April 2011*: Discussion about collected data for systems analysis between the transition team members and policy officers from other departments within the municipality in an expert meeting. *9 May 2011*: First transition arena workshop, in which the (preliminary) systems analysis was presented to the participants of the transition arena, by the transition team. Enables an effective exchange of perspectives between the participants of the arena. Results from the first transition arena session are discussed within the transition team and are used to modify the systems analysis. *May 2011*: Transition team processes input from the first arena session to improve systems analysis. *7 June 2011*: Second transition arena workshop, with the same participants as the first transition arena session, together with the transition team. Results in in-depth expansion of systems analysis, priorisation of themes and a first draft of goals for the future. *June – October 2011*: Transition arena workshops aimed at envisioning and agenda setting build upon the systems analysis.

Table 3 *Application of the systems analysis in Aberdeen*

Step	Application in Aberdeen
1 System definition	*May 2011* – System definition based upon discussions in transition team meetings, by the policy officers and city coach. Transition team analyses data from existing policy documents and plans, and conducts first interviews with potential participants of the arena.
2 System structuring	*May-June 2011* – Collected data are systematically analysed to inform and form a historical analysis and a SCENE model. The system structuring is realised by the transition team.
3 Data gathering	*April-June 2011* – Data collection from existing policy documents, plans and databases existing in the municipality. First data collection is realised by policy officers from the transition team. Data collection involves 5 in-person interviews with potential participants following semi-structured open questions about problems, challenges, strengths and weaknesses of the city and the energy sector.
4 Data assessment and analysis	*June 2011* – During the first transition arena workshop, the transition team presents the systems analysis to the participants. Discussions and inputs from the participants results into adapting the system structuring. *September 2011*- During the second transition workshop, new participants point at themes and issues revealed by the system analysis resulting in expansion of system definition and boundaries: inclusion of mobility into the broader system definition.

Below, we use the results of the systems analysis in Ghent to illustrate possible outcomes of the systems analysis (based on Maas, 2011; van Sande, 2011). Box 1 presents the outcomes according to the lenses, following the gliding scale from macro to micro level, as shown in Table 1. Table 4 illustrates the state of the city system from the perspective of the transition team of Ghent, as well as that of Aberdeen, from the perspective of their respective transition team. It provides an overview of the stocks and characteristics that are identified as most important in the social, environmental and economic domains, relevant to the energy and climate context in Ghent and Aberdeen. Information on these stocks and characteristics was gathered in a background document and served the further exploration and analysis of the system, in terms of relations, trends and main assets (see Box 1). To fuel the discussion on the relations in Ghent, a few stocks were highlighted in the synthesis by the transition team: *mobility and infrastructure*, *housing*, *economic vitality*, and *health.*

Furthermore, a system model was developed to map the relations between the stocks, and to investigate linkages between the different components of the system. This system model generated insight in (unintended) effects that can be expected when changing one part of the system and in linkages that provide opportunities for change. An example from Ghent was the relation between social housing and energy use. Ghent has a large social housing stock, with houses of relatively poor quality and low energy efficiency (e.g. lack of double glazing, poor insulation, and lack of central heating). It turned out that there might be a great potential for increasing energy efficiency and living quality by renovating and retro-fitting these houses using low-carbon technologies. This improvement could lead to both increased energy efficiency and living quality, as well as to lowering energy bills, of major importance to the poorer segment of society that often live in social housing.

The stocks were placed within the physical and institutional context, as they influence the developments in the city. Relevant physical factors in Ghent were for example the large amount of protected monuments, limiting adaptation of buildings and retro-fitting, and flood vulnerability. A relevant institutional factor for Ghent was the challenging political reality in Belgium, which had led to a political deadlock in the past because of disagreement between the three political regions. This had resulted in a complex division of responsibilities between the federal government and the regional governments.

Six main assets of Ghent were identified (see Box 1), on the one hand to emphasize the assets the city can build upon to reach a climate-neutral future, on the other hand to frame the challenges related to these assets. Finally, an inventory of existing innovative projects in the city was made, in order to investigate the possibilities and barriers for good practices, and look into ways to stimulate take off of these desired developments (see Box 1).

The trend analysis was done, but did not really ‘land’ with the policy officers from the transition team and the participants of the transition arena. The main assets that were identified were plotted over time, to show increases and decreases of the assets, but this did not manage to communicate situations of improvement and situations of unsustainability as expected.

Box 1 *Outcomes of the systems analysis in Ghent*

<u>Macro level</u>

Landscape influences

Many developments and trends at a higher level (e.g. national, European and global level) influence the institutional organisation and policy developments at city level. Worldwide, the attention for climate change has exploded in the past decades, both scientifically and politically. In order to combat climate change, CO_2 emissions from fossil energy sources have to be reduced. Furthermore, fossil-based energy supply is highly vulnerable to conflicts, scarcity of resources and rising prices. These factors combined give rise to the need to reduce energy use, reduce CO_2 emissions and to switch to renewable energy sources. Belgium is one of the most prosperous countries in the world. Subsequently, the ecological footprint of Belgian citizens is very large: they rank as the 4th in the world. If the entire worlds' population would live as the Belgians do, we would need more than 4 times the surface of our planet: earth cannot sustain this level of consumption (van Sande, 2011). The financial crisis and subsequent recession of the past years have revealed the vulnerability of the global economic system (Dahl, 2009). This provides opportunities for rethinking the economic growth paradigm and deliberating alternatives more aligned with sustainability. The financial crisis and economic recession have shown that the 'green economy' is more resilient: green companies with green jobs have withstood the crisis well and represent a remarkably healthy economic sector.

Historical sketch

Ghent is a historical city, and settlements on the site of the contemporary city reach back until Celtic times, around 500 B.C. Ghent was located in a marsh area, which made it unsuitable for agriculture, but where sheep breeding was possible. This led to a flourishing wool industry, and later on the production of other fabrics, which gave Ghent the name of "the Manchester of the European mainland". From around 1000 to 1500 A.D., Ghent was the biggest city of the low-lying countries and was bigger than Cologne and Paris. In the 13th century Ghent was home to around 60.000 inhabitants. Ghent has always been a rebellious and wayward city. Its inhabitants fought for hundreds of years against the repression of their rulers and strode for their freedom and privileges. Even now, rebellious people in Ghent are still referred to as *stroppendragers* ('knot wearers'), because the inhabitants of Ghent were punished by wearing a hangman's knot for revolting against Emperor Charles V. From the 16th to 18th century, the city Ghent suffered from economic decline. The population decreased from 60.000 to only half that size around 1630 and the city lost power over the access to the channel that gave access to the North Sea. An economic upswing was brought about by the introduction of industrialized linen and cotton production. Ghent was the first city on the European mainland that became industrialized during the Industrial Revolution at the end of the 18th century. Around that time, Ghent also became a true university city and opened its sea port, with a connection to sea through the newly dug Ghent-Terneuzen channel. In 1827 the first gas factory in Belgium was built in Ghent to provide the street lanterns with gas. Soon after, two others were opened. From 1860 onwards, most of the industry settled outside of the city. Also, the last city gates were broken down, allowing for the construction of new neighbourhoods outside the historic city walls. Ghent was the first city to have labour unions, and was the birthplace of the socialist movement in Belgium. The Vooruit, the historic labour union stronghold and socialist party centre, is still a dominant feature in the centre of Ghent.

Because Ghent was not bombed during the two world wars, its many historical buildings have been preserved. From the 1950s and onward, Ghent was an industrious, but grey and polluted city. The streets and quays were clogged with cars, and the water in the canals was black and smelly. In the 1970s local politicians took some important decisions to improve the situation in the city. In general, there was a shift from a typical industry city towards a service- and knowledge-based economy. The municipality demarcated part of the centre as a traffic-free zone, the most prominent quays in the centre became traffic-free and the water quality was greatly improved. The water became the lifeline of the city again and the quays, such as the *Graslei*, are a hotspot for inhabitants and tourists during summer to enjoy outside life alongside the canal. Furthermore, there were big investments in cultural activities, most famously the introduction of the *Gentse Feesten*: the Feasts of Ghents, a renowned festival.

Looking back, political decisions made 40 years ago (e.g. introduction of traffic-free zones, improvement of water and air quality, introduction of cultural activities) had a big impact, and are still visible when looking at the current situation in the city. They provide an inspiration for the political decisions that have to be made now to ensure Ghent will be a liveable city 40 years from now.

Meso level

Main assets

Knowledge city: strong presence of university and students, but link to practice is weak.

Prosperous city: strong high-tech sector, but also need for production of local goods and lower-skilled employment.

Water city: water is the lifeline for the harbour, tourism and citizens, but the transport potential is underdeveloped and climate adaptation can become a challenge.

Green city: Ghent has abundant green space, but many citizens do not have sufficient access to them. They live too far away.

Energy city: Some companies in Ghent are real frontrunners in renewable energy, but the presence of the fossil-energy sector remains strong.

Lively city: Ghent is a welcoming and buzzing city for citizens and tourists, but social cohesion is a weak spot in some areas and the main festival – De Gentse Feesten – has become so famous that people from Ghent do not feel it is their festival anymore).

Dominant culture, structure and practices

Ghent's political structure is mostly aimed at securing short-term success, in order to get public support and get re-elected. This political short-termism makes it very difficult to introduce innovations and policies that take longer than a legislative period to prove their value.

Within the organization of the municipality, the different departments do not always work together or differ greatly in their way of thinking on issues that involve multiple policy domains, leading to fragmented, inefficient and sometimes even contradictory policies.

Other characteristics of the city are: the shift from government to governance, the city's history of political consensus and dialogue, overregulation, stubbornness of the inhabitants, local pride regarding the city's heritage, and modesty about their frontrunner status.

Micro level

Identification of niches

Innovative niche developments are:

Ghent Bio-energy Valley: a public-private partnership (e.g. Municipality and Province of Ghent, Port of Ghent, Ghent University and several companies) to stimulate the bio-based economy and the production of sustainable bio-energy.

Gasmetersite: a new housing development on a former brownfield, with passive and low-energy houses and space for renewable energy generation.

Other stimulating niche activities are the mayor coming to his office by bike, taking away prejudices about biking to work being unprofessional or uncomfortable; and companies providing their employees with a foldable bike, instead of a (lease) car.

Table 4 *Domains, stocks and characteristics of Ghent and Aberdeen*

	Ghent		Aberdeen	
	Stocks	**Characteristics**	**Stocks**	**Characteristics**
Environmental domain	Water	Surface water	Environment	Drinking water
		Water quality		Water use
		Water use		
	Green space	Surface forest and nature		Quality public space
		Public green space		Green infrastructure
		Green roofs		Urban parks and gardens
	Energy	Energy prod./cons.		
		Renewable energy		Greenhouse gas emissions
		Energy infrastructure		
	Waste, soil and nuisance	Municipal waste		Household waste
		Soil pollution		Industrial waste
		Nuisance		Air quality
	Air pollution	Air quality		Flood prone areas
		Fine particulate matter		Ecological footprint
		CO_2 emissions		

Social domain	Population	Population density	Demographics and settlements	Population density
		Demographics		Demographics
		Immigration/emigration		Suburbanisation
	Housing	Ownership	Housing	Housing types
		Housing types		
		Energy performance		Land Use
	Social services	Education		
		Healthcare		
		Associations		
	Liveability	Satisfaction of living	Liveability	Safety
		Social cohesion		Health
		Segregation		Social deprivation
				School attendance
				Cultural institutes
	Leisure	Sports	Tourism and leisure	Sports
		Culture		Culture and art
		Lifestyle		Tourism
	Participation & politics	Participation possibilities	Politics	Voter participation
		NGOs		Citizen participation
		Political attention climate		Social cohesion
Economic domain	Mobility & infrastructure	Car use	Mobility	Car ownership
		Public transportation		Public transportation
		Infrastructure		Mobility Infrastructure
	Economic vitality	Income	Economy	Income
		Unemployment		Unemployment
		Educational level		Educational level
	Economic sectors	Harbour	Energy	Energy production
		Knowledge institutes		Renewable energy
		Services		Heating (district, central)
	Knowledge & innovation	Knowledge economy	Knowledge economy	University-municipality collaborations
		(Green) investments		Education level
			Low Carbon Economy	Governance responsibilities
				Green Investments

4. Discussion

Below we reflect upon the application of the systems analysis methodology in Ghent and Aberdeen and draw lessons for future applications.

Reflection

An overview of the state of the system revealed interesting connections

In both Aberdeen and Ghent, the climate and energy goals of the municipality were the reason to get involved with the MUSIC project. Therefore, the identification of stocks was strongly focused on this realm. However, the SCENE model greatly aided in forcing to take a wider perspective of the system, and getting an overview of the whole.

In Ghent, the stock 'energy' was placed in the environmental domain; despite the importance it has for the economic domain, since Ghent historically has been a big steel- and electricity producer. This can be explained by the energy and climate focus that the municipality took for this project: energy is mainly viewed in terms of emissions (harmful to the environment), or in terms of the switch to renewable energy (beneficial to the environment); it is mainly framed in terms of its environmental impact. At the start of the systems analysis the policy officers showed some surprise at seeing the proposed stocks suggested by the developers of the methodology mainly in the social domain, such as 'housing' and 'social services'. It was felt that these had no clear relationship to the focus of the project: climate and energy. However, later in the process, after data gathering, interviews and discussions, it became apparent that there are some very interesting links between housing, social services and energy, such as possibilities for sustainable social housing and a social benefit scheme to prevent energy poverty among poorer groups in society.

In Aberdeen, the application of the SCENE model for mapping stocks into three core sustainability domains revealed the policy logic behind understanding the operation of each stock for specific domains. Policy officers initially placed 'energy' as an economic asset of the city. The rationale behind this perception was that the energy sector is providing employment to the city and it is coupled to its economic vitality. During the discussions and reflections on this energy-employment couple, the officers shifted their understanding in two ways. Firstly, the policy officers recognized that energy assets (oil, wind, etc.) are part of the environmental assets and provide economic services instead of only being perceived as part of the economic fabric of the city. Second, energy initially was the asset of the city that was connected directly or indirectly with all characteristics and services of the city. During discussing what constitutes the fabric of the city, policy officers addressed additional assets such as education, trade, agriculture and art as important characteristics of the city that are not directly relating to the energy sector per se.

The analysis of the history inspired and motivated participants

In both cities, the analysis of the history of the city gave insight in the importance of historical events and developments, and created a feeling for the possibilities in the future.

In Ghent, the historical sketch, depicting major events and developments in the past of the city provided some interesting perspectives for the future. The characterisation of the inhabitants of

Ghent as being rebellious and taking up a role as frontrunners can be used to position and frame the ambitious policy choices made today. Radical policy choices made in the 1970s – including the creation of a traffic-free zone in the centre of the city and the improvement of air and water quality – provide an inspiration for the political decisions that have to be made now to ensure Ghent will be a liveable city 40 years from now and show how much can change in this relatively short time span.

In Aberdeen, the presentation of the history of the city created a feeling for its future. During the transition workshop, the participants shared their (family) stories about the past, and in this way they connected personal memories with historical events and path-dependencies. Stories about the cultural heritage and activities of the community in different seasons and the changes in culture that were brought by the newcomers that are employed in the energy sector have been shared and expressed. The participants shared a feeling for the need to regain 'ownership' of the future of their city and "to live to its true potential".

The systems analysis broadened the problem perception which was considered valuable by the participants

In Ghent, dialogue within the transition team, discussions between the transition team, experts and participants of the transition arena, and the execution of the systems analysis enabled broadening the problem perception from the narrow focus on climate and energy towards a more holistic approach to the problem. This led to the broadening of the initial problem formulation from "How can Ghent become climate neutral in 2050?" to "How can Ghent become climate neutral in a context of becoming a social, green and liveable city in 2050?" Historical characteristics and current assets of the city of Ghent, such as its social and green character and strong cultural sector, were thus linked to the ambition of CO_2 emission reduction and a transition to renewable energy. Widening the problem space, by adopting a holistic perspective on the system, was deemed very valuable by the members of the transition team and the participants of the transition arena in Ghent. For example, the inclusion of social aspects while talking about climate and energy goals led to insights and opportunities that would otherwise have been missed. Having an integrated perspective shows that climate and energy issues do not exist in a vacuum, but need to be considered in relation to other policy domains in order to look for the deeper lying problems and opportunities for improvement. As a participant of the transition arena expressed: "This is a method for participation where the level of knowledge is increased and complexity of the subject is acknowledged" (Roorda et al., 2012).

The systems analysis revealed institutional barriers to sustainable development

Differences in institutional logic of every municipality were revealed during the dialogues about the domains of change and persistent problems in the transition teams of both Aberdeen and Ghent.

Aberdeen's governance is characterized as pragmatic, meaning that policy agenda's points have to relate one to one with the issue at hand, and only realistic top-down measures can be included in policy action plans. Any innovation that requires 'creative' arrangements between departments of the municipality that do not pre-exist are screened out as infeasible. The pragmatic approach to governance yields fruits on the short term. However, long term changes that may be required to address an issue such as climate mitigation are confronted with a strong avert governance reality.

Ghent's political structure is mostly aimed at securing short-term success, in order to get public support and get re-elected. This political short-termism makes it very difficult to introduce innovations and policies that need a time span longer than a legislative period to prove their value. Besides a long-term perspective, sustainable development requires an integrated, holistic approach. However, within the organization of the municipality, the different departments do not always work together or differ greatly in their way of thinking on issues that involve multiple policy domains, leading to fragmented, inefficient and sometimes even contradictory policies.

In Ghent, the systems analysis has forced the policy officers involved, as well as the experts who participated in the expert session, to think more holistically about energy policy at local level and promote cooperation between different departments of the municipality. Discussing the systems analysis in a trans-disciplinary group greatly aids in the process of stimulating holistic thinking. However, there were also difficulties with thinking holistically in the session with the transition team, the expert session and the transition arena sessions. There is a clear need for a transition from compartmentalized thinking towards holistic thinking. The fact that data gathered through desk research was complemented with insights and perspectives of experts (in the expert session) and actors (through interviews) was considered very valuable by the members of the transition team of Ghent. It made them realize how little they know about the city they live and work in, and in how many possible ways one can look at an issue.

In Aberdeen, systems analysis discussions between policy officers and the city coach, as well as the transition workshops with a variety of frontrunners, stimulated holistic thinking about the problem and its root causes. More specifically, during the systems analysis discussions, a first step to decouple the city's growth from carbon growth emerged in the policy officers' perceptions. During the dialogue with the policy officers, the problem perceptions have been shifted from anchoring the oil-industry for city's prosperity towards seeking possibilities to maintain and expand the city's prosperity. The understanding that the city consists of more economic assets than the oil industry alone and that different assets also contribute to the city life was a first step in decoupling city's growth from carbon growth. A second step to decouple city's growth from carbon growth was proposed by workshop participants. Two participants started questioning the reality that "oil rules the city" and argue about the need to start a new social fabrication of the city's growth looking outside the energy-economic growth couple. They mentioned Tim Jackson's *Prosperity Without Growth* (2010) ideas and growth perspective as indicative for what can create a shift in thinking and understanding.

The systems analysis served as a catalyser for mutual understanding and learning between the participants

The difference in backgrounds and perspectives of the people involved in the systems analysis could have posed problems in the discussions. However, in Ghent, the systems analysis helped to overcome this. The participants recognized their perspective was integrated in the systems analysis, so they recognized it as "theirs" and gained ownership of the results of the systems analysis. Moreover, discussing the systems analysis served as a catalyser for mutual understanding and learning between the participants. It made the discussions go beyond platitudes and symptoms. The level of knowledge on sustainability issues ranged widely, but still all participants say to have learned from other participants and most say to have gained new insights with respect to sustainability. The

transition arena did however inhibit a delicate balance: some participants wanted to have more in depth discussions and research, others asked for more speed in the process and were eager to get more concrete. In general, the participants of the transition arena sessions highly valued the diverse background of the arena participants and the variety of technical information and perspectives brought to the foreground by the systems analysis. Some illustrative quotes are: “I learned a lot due to the mixed background of the arena participants” and “I valued the mix of technical knowledge and different backgrounds” (Roorda, 2012).

The systems analysis falls short in creating a sense of urgency

According to city coach of Ghent, describing the landscape influences was very useful. It was essential in communicating the urgency of the problem and triggered a lot of discussion, such as on the concepts of ‘ecological footprint’ and ‘climate neutrality’”. However, even though the systems analysis has managed to give a synthesis of different facts and perspectives, it falls short in communicating the urgency and motivation to tackle the problems at hand. It is too much of everything; a clear story line is missing (Maas, 2011).

In Aberdeen, creating a sense of urgency worked out better. The system analysis revealed the heart of the energy problem rather than justifying precluded solutions (e.g. subsidizing renewable energy). By revealing the strong dependency of the city’s economy on the energy supply sector as it is formed at present, a sense of urgency was created.

Lessons learnt

How to apply the systems analysis methodology should be discussed among the participants and tailored to the characteristics of a city

Discussions on *how* to implement the methodology in the context of a specific city in the transition team and with other experts and actors turned out to be essential. This is important, because it is necessary to come to a mutual understanding about the systems analysis methodology as well as of what constitutes the system. Every city is different and thus the composition of stocks and their characteristics within the sustainability domains varies. Energy use in one city may for instance be placed in the environmental domain (as was the case in Ghent), because it is mainly viewed as a source of CO_2 emissions, whereas in another city it may be considered the fuel that drives the industrial economy and therefore it is placed in the economic domain (as was the case in Aberdeen).

The placement of stocks, and their characteristics should be thoroughly discussed to ensure it makes sense for the participants as well as for the specificities of a city. In Ghent, the identification of flows turned out to be difficult for the people filling in the SCENE model. They discussed about the difference between flows and relationships between stocks. And whether a flow should be a tangible flow of matter, information or emissions, or whether it can also be used to describe a causal relation. In Ghent it was decided to name interrelations between stocks and give an overview of the stocks and the relations between them in a system model, to cover all of these types of interrelations.

The different lenses that were applied to analyse the data gathered by means of desk research, expert sessions and interviews were not all used in the two cities, or were used in a different manner. In Ghent, most of the lenses have been used, and proved useful. In Ghent, the lack of a

strong trend analysis, which is meant to show unsustainable pathways and unsustainability problems for the future, is an explanation for the weak sense of urgency amongst the members of the transition team and the participants of the transition arena.

The systems analysis methodology as it is presented in this paper is not a cookbook; it should be applied flexible and tailored to the local situation.

The methodology should be used in a flexible way; it should not be understood as a clear recipe that can be applied everywhere in the same way. Every city, and the participants in the transition process, is different. The form of the systems analysis, why it is used and which goals should be set to accomplish that should be made clear. Before conducting the systems analysis, it is important to voice expectations, make a realistic planning and decide upon the form of presenting the data, in order to present the systems analysis in such a way that it fits with the target audience. Discussions in the transition team were essential to come to a common understanding of the system and a working method for the systems analysis.

5. Conclusions

The systems analysis methodology we present in this paper enriches the start of a transition management process in an urban setting. The methodology consists of the following four steps that need to be followed in an iterative way: (i) system definition, (ii) system structuring, (iii) data gathering and (iv) data assessment and analysis. Characteristic of this methodology is the use of a set of lenses that reflect a variety of ways of looking at the system from macro, meso, and micro level. Together, these lenses ensure an integrated perspective and thorough analysis of a municipality. The systems analysis methodology as we propose it involves a variety of stakeholders: the transition team, consisting of policy officers from the municipality, a city coach and a process manager, who initiate the transition process and organise and facilitate the transition arena workshops. Because integration of objective data and subjective perspectives is crucial, desk research as well as interactive research – interviews with frontrunners, expert meetings and workshops with frontrunners in the transition arena – is needed to collect and analyse the data.

The methodology we propose should not be interpreted as a cookbook. Every city is different with respect to the local context and customs, and every group of participants differs in background, involvement and knowledge. Therefore, the methodology should be applied flexible and tailored to the local situation.

The steps of the systems analysis methodology should be thoroughly discussed in the transition team. It is particularly important to agree on the purpose of the systems analysis, on what constitutes the system and to come to a mutual understanding about the systems analysis methodology. This discussion can reveal interesting and new opportunities for change, such as unexpected connections, possibilities for synergy, and new perspectives on the problem. This is illustrated by the example of 'housing' in Ghent and the problem perception in Aberdeen. Policy officers from Ghent at first instance did not see the connection between 'housing' and climate and energy, whereas later on in the process 'housing' became a focal point, because of interesting opportunities related to sustainable social housing and social benefits related to housing. In Aberdeen, the problem perception shifted from anchoring the oil industry for the city's prosperity towards seeking possibilities to maintain and expand the city's prosperity by making use of all assets of the city, not only those related to oil and gas. The systems analysis has opened up possibilities for synergy; it shows that costs in one domain can lead to benefits in other domains or sectors. By broadening the solution pathways, the holistic perspective on the system allows for the exploration of opportunities that were before deemed unprofitable.

The systems analysis serves as a catalyst for mutual understanding and learning, and stimulates holistic thinking. Participants involved in the systems analysis learn from each other. The systems analysis also reveals institutional barriers such as short-term thinking and policy fragmentation to sustainable development, but it is not able to overcome these barriers. Obviously, institutional transition requires a long period of time and the systems analysis only constitutes the first phase of transition management. The political and institutional context remains a focus in the subsequent phases of the transition process.

Overall the systems analysis methodology is an effective method to create an overview of the municipality under study, and stimulates the creation of a common information base and holistic thinking amongst participants in the transition process. It serves as a good start for the transition management process; the participants share a perspective on the system, its properties, challenges and opportunities, and use the systems analysis as a basis to continue working on viable solution pathways to enable their city to reach their ambitious climate and energy goals.

References

Balthazar T., 2008. Stad Gent Lokaal Klimaatplan 2008 - 2020. 105 acties voor een klimaatneutrale stad. Stad Gent, Departement Milieu, Stadsontwikkeling en Wonen, Ghent.

Banathy B.H., 1988. Systems inquiry in education. Systemic Practice and Action Research. 1, 193-212.

Covenant of Mayors, 2011. The Covenant of Mayors. Website of the Covenant of Mayors.

Dahl A.L., 2009. Financial Crisis and the Green Economy. International Environment Forum, UNEP/University of Geneva/Graduate Institute Certificate of Advanced Studies in Environmental Diplomacy, Geneva.

European Commission, 2010. The EU Climate and Energy Package. European Commission, Climate Action, Brussels.

Findeisen W., Quade E.S., 1985. The Methodology of Systems Analysis: An Introduction and Overview, in: Miser H.J., Quade E.S. (Eds.), Handbook of Systems Analysis: Overview of Uses, Procedures, Applications, and Practice. Elsevier Science Ltd., New York, pp. 117-149.

Grosskurth J.A., 2008. Regional sustainability: Tools for integrated governance. International Centre for Integrated Assessment and Sustainable Development, Maastricht University, Maastricht.

Jansen K., 2009. Implicit sociology, interdisciplinarity and systems theories in agricultural science. Sociologia Ruralis. 49, 172-188.

Loorbach D., 2007. Transition Management: New Mode of Governance for Sustainable Development. International Books, Utrecht.

Loorbach D., 2009. Urban transitions and urban transition management. The case of Rotterdam. Workshop on Urban Transitions, Manchester.

Maas S., 2011. Making Sense of Complex Systems. A Systems Analysis Methodology for Urban Transition Management: the case of Ghent and its climate ambitions. Wageningen University, Wageningen.

Miser H.J., Quade E.S., 1985. The Context, Nature and Use of Systems Analysis, in: Miser H.J., Quade E.S. (Eds.), Handbook of Systems Analysis: Overview of Uses, Procedures, Applications, and Practice. Elsevier Science Ltd., New York, pp. 1-32.

MUSIC, 2011. Mitigation in Urban areas: Solutions for Innovative Cities. The MUSIC Project, Rotterdam.

Newman P., Jennings I., 2008. Cities as Sustainable Ecosystems: Principles and Practices. Island Press, London.

Roorda C., 2012. Presentatie: Resultaten enquête transitiearena Gents Klimaatverbond. Drift, Stad Gent, Ghent.

Roorda C., Broers W., van Eijndhoven J., Kimman J., Kortman J., Loorbach D., Manders H., Tiekstra C., 2011. Analyse koploperprojecten - praktijkervaringen en aanbevelingen uit interviews en literatuur. Transitie in energie en proces voor duurzame gebiedsontwikkeling (EOS LT: TRANSEP-DGO), Rotterdam.

Roorda C., Maas S., Frantzeskaki N., Fortuin K., 2012. Systems analysis for urban sustainability transitions. A joint understanding of complexity and dynamics. 3rd International Urban Research Symposium, Belo Horizonte.

Rotmans J., 1998. Methods for IA: The challenges and opportunities ahead. Environmental Modeling and Assessment. 3, 155-179.

Rotmans J., Kemp R., van Asselt M., 2001. More evolution than revolution: transition management in public policy. Foresight. 3, 15-31.

Rotmans J., Loorbach D., 2009. Complexity and Transition Management. Journal of Industrial Ecology. 13, 184-196.

Saravanan V.S., 2008. A systems approach to unravel complex water management institutions. Ecological Complexity. 5, 202-215.

Swart R., Raes F., 2007. Making integration of adaptation and mitigation work: mainstreaming into sustainable development policies. Climate Policy. 7, 288-303.

van der Brugge R., 2009. Transition Dynamics in Social-Ecological Systems: The Case of Dutch Water Management. Erasmus Universiteit Rotterdam, Rotterdam.

van Sande I., 2011. Presentatie Systeemanalyse, Transitie Arena 1. Stad Gent, departement Milieu, Ghent.