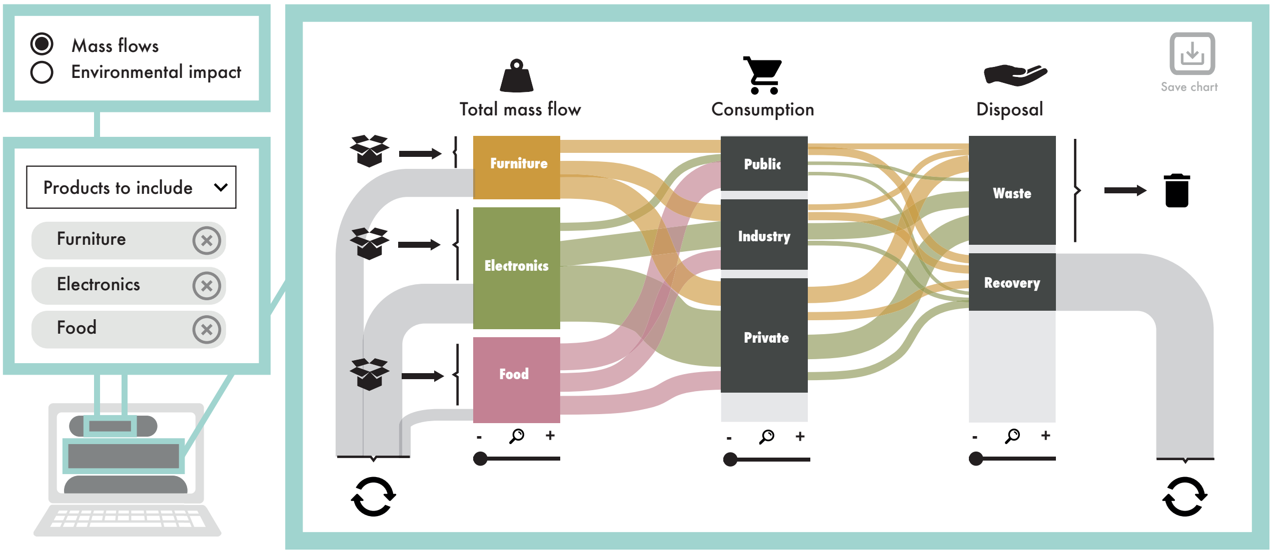

Adapting the Urban Metabolism Analyst Model for Practical Use within Local Authorities

Challenge Lab 2018: Sustainable Urban Development

Master of science in Industrial Design Engineering

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Cover: Visualisation of components in conceptual software developed to increase accessibility of the UMAn model. More information can be found on page 39.
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Abstract

Material Flow Accounting (MFA) studies, providing analyses of the metabolism of a given system, are receiving increased attention due to their potential in supporting planning and policy making for efficient resource use. In this capacity, they are becoming increasingly relevant to apply for urban areas by a variety of actors. This trend provides opportunities for research on user centred approaches and collaboration between academics and practitioners in the development of urban-level MFA models. With specific focus on the Urban Metabolism Analyst (UMAn) model, this thesis, carried out within Challenge Lab at Chalmers University of Technology, investigates how MFA data may be made more available for practical use. A case study of the project Circular Gothenburg within Gothenburg municipality is studied to anchor the investigation in specific user needs. Two research questions are addressed; (1) *What types use could Circular Gothenburg have of the UMAn model* and (2) *How can data from the model be made more intuitive and user friendly*? By adopting a user centred approach with emphasis on qualitative and interactive methods, concepts were created in collaboration with Circular Gothenburg and the UMAn research team, with attention to both needs and the possibilities of the model. The results display how data from the UMAn model can become more available through a conceptual software, consisting of several - and for Circular Gothenburg, relevant - components. The main value provided through this conceptual software is an understanding of the product and material flows being consumed within the city and their respective environmental impact. It further displays ways of visualising the data which may serve as a foundation for future work. The results suggest that the most relevant application of UMAn lies within planning and prioritising, and that greatest value is achieved when the data is combined with Life Cycle Assessment. Moreover, they show that there indeed is an interest in developing UMAn for more practical use, and that more research must be done before it can be practically applied.

Keywords: Material Flow Accounting, the Urban Metabolism Analyst, Transdisciplinary research, User centred approach.

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We want to further extend our gratitude to other members of the UMAn research team for their time and knowledge inputs.

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Finally, we want to give the warmest of thanks to our fellow Challenge Lab students for their continued support, inspiration and open and warm atmosphere within the Lab.

Table of Contents

1. Introduction

Material Flow Analysis (MFA) studies, which examine the metabolism in a given system, have in recent years been acknowledged as aiding tools for priorities and policy making in material and waste management (Hendriks et al., 2010; Binder, 2007; Brunner & Rechberger, 2017). In this capacity, results of MFA studies are important information inputs to circular economy development (Schiller, Gruhler & Ortlepp, 2017). One MFA based model, currently developed at Chalmers University of Technology, is the Urban Metabolism Analyst (UMAn). This model adjusts MFA to the characteristics of urban areas and provides region specific data on material flows (Rosado, Niza & Ferrão, 2014). To this end, some scholars contend that the UMAn model can contribute to region specific development of circular economy strategies (Kalmykova & Rosado, 2015).

As is the case with many research based models, the results of metabolism studies are, despite their theoretical usefulness and relevance, seldom used. This is partly due to difficulties connected to their practical application (Binder, 2017; Kennedy, Pincetl & Bunje, 2011). Amongst such difficulties lays interpretation of MFA results which is problematic because goals within material management are seldom clearly defined (Binder, 2017) and because there are no established principles for determining system boundaries (Voskamp et al., 2016). As the validity of these models depend on the input data, access to sufficient amounts of reliable data is also an issue (Zhang, 2013), which on an urban level is very limited (Rosado, Niza & Ferrão, 2014). Moreover, there is a lack of a general framework for MFA, meaning that studies are evaluated separately and general conclusions cannot be drawn (Brunner & Rechberger, 2017; Rosado, Niza & Ferrão, 2014). Being based on MFA, this thesis assumes that the UMAn model presents similar difficulties.

The UMAn model has previously been applied for research purposes in the Metropolitan area of Lisbon (Rosado, Niza & Ferrão, 2014), Stockholm, Gothenburg and Malmö (Rosado, Kalmykova & Patrício, 2016) to examine local metabolism characteristics and provide overviews of material flows. Although there is a long way until MFA models become standardised practical tools in resource management, they are becoming more relevant to apply in cities or municipalities by a variety of actors (Brunner & Rechberger, 2017). This development presents new opportunities for research on user centred approaches and collaboration between academics and practitioners in the development of MFA based research models. This is what will be explored in this thesis.

1.1 Research aim

By providing an overview of the needs of one potential user group; the project "Circular Gothenburg" within Gothenburg municipality, this thesis aims to investigate how the UMAn model could be developed for more practical application. The goal of this investigation is to provide suggestions on how to increase the model's accessibility which in turn may enable a broader basis for decisions impacting the city's metabolism. A secondary goal is to initiate relations and collaboration between users and model developers. To fulfil this aim, two research questions will be explored:

1. What types of use could Circular Gothenburg have of the UMAn model?
2. How can data from the model be made more intuitive and user friendly?

1.2 Delimitations

Circular Gothenburg will act as case study for this thesis, and focus will lay specifically on the overall project and two ongoing sub-projects. Needs will be mapped in relation to those focuses, however needs that cannot be fulfilled using the UMAn model will not be considered in the development of concepts. As the thesis is carried out with this user in mind, concepts will be developed specifically for them.

Concepts based on the UMAn model will serve as representations for how relevant data can be made more available and user friendly. This means that focus will lie on visualisation strategies and not on delivering accurate data.

1.3 Reader's guide

If you as a reader find particular interest in a certain part of this thesis, this guide may direct you to the relevant chapter.

Chapter 2 describes how the research questions were identified using the Challenge Lab approach and its core methodology - backcasting.

Chapter 3 presents the theoretical framework and briefly explains the research areas concerned in this thesis; transdisciplinary research, design thinking, circular economy, urban metabolism, material flow accounting, the urban metabolism analyst model and finally visualisation strategies for flow data.

Chapter 4 presents the methods used and how they were applied in the different steps of the thesis process.

Chapter 5 gives insights from the case study of Circular Gothenburg, which provide context for the following chapters.

Chapter 6 presents the development of concepts based on the needs of Circular Gothenburg and the potential value of the UMAn model. This chapter explains the highlighted results from the design process of concept ideation and evaluation.

Chapter 7 presents the final concept and suggestions for future work.

Chapter 8 discusses the meaning and implications of the results and evaluates the project process as well as the user centred approach which has been adopted throughout.

Chapter 9 provides the concluding notes.

2. The process of identifying research questions

This chapter is presented to provide an understanding of the master thesis approach applied within Challenge Lab and how it shaped the initial phase of the project. The approach differs from conventional master theses at Chalmers in that it dedicates a fifth of the work to identifying the research questions and takes into account the personal interests and values of the students carrying out the work.

2.1 The Challenge Lab approach

Challenge Lab at Chalmers University of Technology, which was first initiated in 2014, is a lab-based learning arena where students, researchers and actors from public and private sectors gather around sustainability challenges (Larsson & Holmberg, 2018). It is a neutral space that provides an opportunity for stakeholders from the region to meet on equal terms. The activities in the Lab are connected to five active knowledge clusters in West Sweden; Life Science, Transport, Chemistry, Maritime and Urban Future. In the Challenge Lab setting, students act as neutral change agents, leading multi-stakeholder dialogues and development processes, and are involved in sustainability transitions as part of education. The process is guided by both outside-in and inside-out perspectives to account for external requirements as well as personal values and intrinsic motivations (Holmberg, 2014). The guiding principle of all work conducted in the Lab is:

Think big - Start small - Act now

The Challenge Lab master thesis approach divides the work into two phases. Phase 1, which accounts for 20% of the project, covers the process of identifying the research questions. Phase 2 is equivalent to, although naturally not as extensive as, a traditional technical master thesis and covers the continuation of the work. Hence, while a more traditional thesis at Chalmers would begin where Phase 2 is initiated, the Challenge Lab approach begins one step back with identification of areas where there is a need for change, actionable leverage points and finally the research question. The core methodology within the Lab is backcasting, which is a planning methodology with its starting-point in a desired future state that can be used for planning under uncertain circumstances (Holmberg & Robèrt, 2000). By focusing on a desired rather than expected future, it sets the search for future solutions free from present systems. While more traditional approaches, such as forecasting or scenario planning, focuses respectively on what the most likely future or set of possible futures will be, backcasting focuses on what future that *should* be, as represented in Figure 2.1 below.

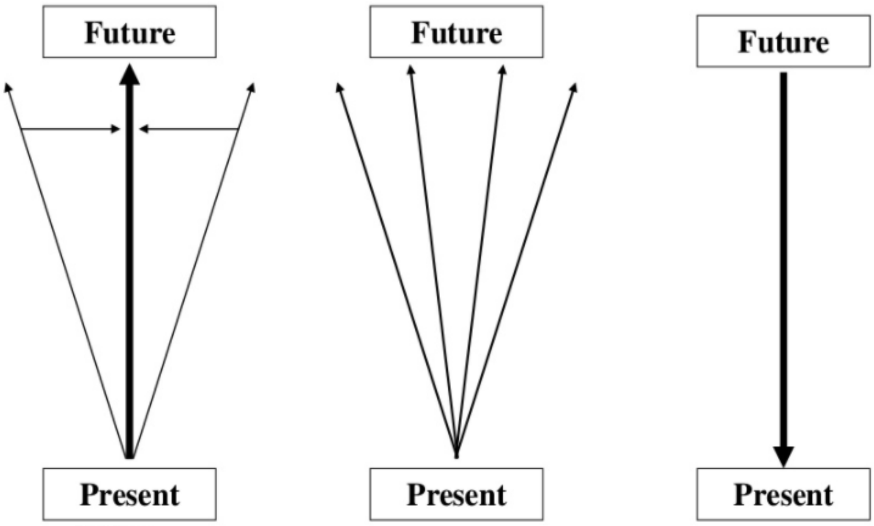

Figure 2.1 - From left to right; visualisation of forecasting, scenario planning and backcasting.

The backcasting methodology as presented by Holmberg (1998) consists of four steps and is typically visualised similarly to Figure 2.2 below. The starting-point is the sustainability principles, framing the desired future and covering the whole spectrum of sustainability dimensions; ecological, economic, social and well-being. The aim of these principles is to anchor the purpose and future goal in actionable visions to inspire change (Andersson, Holmberg & Larsson, 2015). The second step of the process entails viewing current systems in relation to the principles to identify gaps between existing and desired states as well as leverage points where small changes can create large impacts on the system. To bridge the gaps, various solutions are then sought in step three, using design thinking approaches. Finally, in step four, strategies to implement the solutions are formed through entrepreneurial thinking.

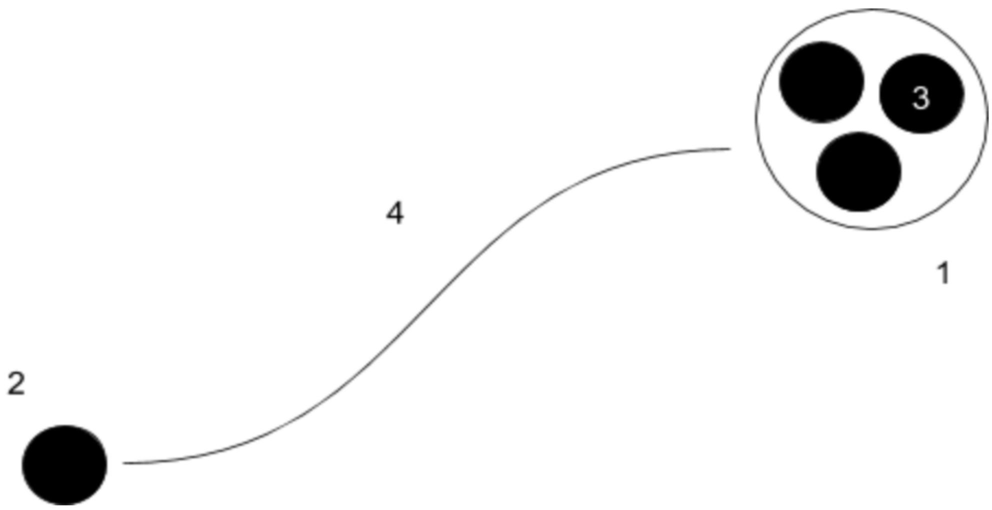

Figure 2.2 - Overview of the steps of backcasting. Own illustration based on Holmberg, (1998).

2.2 Short account of the Phase 1 process

As explained earlier, the aim of phase 1 was to identify gaps between desired and current states, and to formulate research questions within an identified leverage point. This process covered the first two steps of the backcasting methodology. Although phase 1 is an important part of the thesis, the full description of its methodology and results is too extensive to be presented here and has been placed in Appendix 1 for the sake of readability. In this chapter, the most important aspects of the process are accounted for to provide a brief understanding of the approach and project background.

This year's main focuses in Challenge Lab were the thematic areas Mobility, Urban Futures and Circular Products and Services; this thesis falls under the latter category. When formulating the principles that were to guide our projects, the entire Challenge Lab team of 15 students from multiple nationalities and educational backgrounds used the team's collected tacit knowledge on the topic of sustainability to find future goals. Out of the four sustainability dimensions, mainly the economic and ecological ones apply to this thesis since the area of Circular Products and Services is highly concerned with resource use. The guiding principle and driving force in this thesis was the vision of;

...a future where the treatment of our nature is guided by respect, where natural capital is used efficiently with consideration to sufficiency, and where economic activities are carried out with long-term considerations and consciousness.

Comparisons between this vision and the current situation in Gothenburg were primarily done in a multi-stakeholder setting, where dialogue was used as a tool to see where gaps existed and why. Looking at current systems in relation to the principles, the linear economy and consumption behaviours of today caused a large gap between existing and desired states.

In dialogues concerning Circular Products and Services, circular economy was naturally discussed as a possible bridge between the current and desired state. Within those discussions, the concept of Urban Metabolism was brought up as a perspective that could ease the transition towards a circular economy. Urban Metabolism was explained as a research field that assesses the flows of energy, water and materials in a given system (Rosado, 2017). Material Flow Analysis studies were further presented as an important tool for assessing the material flows of systems. Rosado (2017) presented a MFA based model that could provide an overview of the material consumption of cities. Since system change requires understanding of the characteristics and components of the current system, this model was presented as an enabler of more efficient change management related to the use of resources. The issue with the model, which is called Urban Metabolism Analyst (UMAn), was that the data was presented in a way that made it difficult for users to understand it and what it could imply. It was also unclear how the data would be applied by a potential user.

In this gap, there was a leverage point in visualising the data in a way that would make it more intuitive and easy to practically apply. However, these visualisations needed to be anchored in specific user needs to reach concrete results. The user group selected as case study was the project Circular Gothenburg within Gothenburg municipality. This project had been pointed out as one potential user of the UMAn model and was at the time planning for collaboration with the UMAn research team. The final leverage point was then to investigate how the data from the UMAn model could be presented to fit specifically for this user and be made easier to apply practically. In this leverage point, we as authors could contribute with knowledge about the design process, user research, user centred development and service design.

3. Theoretical framework

This chapter describes the framework of the thesis and aim to provide an understanding for the previous research and adopted approaches that constitute the foundation for, and govern, the continuing work. The chapter gives a brief insight into transdisciplinary research, design thinking, circular economy and the connection between those areas. It further presents Urban metabolism and MFA as tools within circular economy and displays the urban Metabolism Analyst as one specific MFA based model. The chapter ends with a section about visualisations of flow data.

3.1 Common problems in transdisciplinary research

Transdisciplinary research, involving both academia and practitioners, can be a successful approach to address issues where demands are posed by both “real-world” problems and science (Lang et al., 2012). In this capacity, it takes a systemic approach to research which has been used to address sustainability challenges that concern all of society. However, integrating actors from different backgrounds in collaborative work presents a number of challenges. Examples described within sustainability science are for instance (i) insufficient problem framing and understanding, (ii) unbalanced ownership of projects, (iii) conflicting methodologies and (iiii) discontinuous participation (Brandt et al., 2013 ; Lang et al, 2012; Schäfer et al., 2010). The first challenge - insufficient problem framing - points to a commonly existing gap between a much needed mutual understanding of the problem at hand and the real situation which often include misalignments of perceptions. This typically occurs when actors have different perspectives or logics (Lang et al., 2012; Schäfer et al., 2010). Unbalanced problem ownership often occurs because most transdisciplinary research projects are initiated by academia. This creates a divergence in ownership which can give rise to problems if it is not balanced (Lang et al., 2012). Conflicting methodologies may also cause a gap between actors (Brandt et al., 2013), and aligning those methodologies requires cognitive integration that links the logics, theoretical concepts and data of several actors (Schäfer et al., 2010). Finally, discontinuous participation primarily concerns practitioners and may give rise to problems if the collaboration is highly dependent on their input (Lang et al., 2012). As transdisciplinary research integrates knowledge of both academia and practitioners, it provides opportunities for grounded and practically applicable results. For sustainability challenges, which concerns all of society and requires collaboration between multiple actors (Geels, 2011), this approach may thereby constitute a desired state of research. Enabling such a research approach requires collaborative and co-creative ways of working.

3.2 Design thinking

Design thinking has in recent years presented a new way of addressing open and complex problems based on design practices and the way designers work (Dorst, 2011). It is an approach that promotes multidisciplinary efforts, co-creation and collaborative mind-sets (Wölbling et al., 2012). The reasoning within design thinking is that end results are viewed in terms of the value they bring. When addressing complex problems, the common strategy is to work backwards from a desired value to identify what needs to be developed and how. In this way, design thinking differs from many other problem solving approaches that instead start with the *what* or the *how*. Although there is no universal process of design thinking, Wölbling et al. (2012) present a common set of five process elements; understanding of the problem, processing data, ideating solutions, prototyping and testing. These elements are typically iterated several times and do not need to take place in any particular order.

3.3 Holistic perspectives in circular economy

Cross disciplinary collaborations and integration of diverse knowledge is crucial to accomplish society-wide sustainability transitions (Geels, 2011). Circular economy, which requires transitions from the current linear economic system, therefore has close ties to both transdisciplinary research and design thinking. Circular economy has in recent years been proposed as a strategy to achieve growth without compromising planetary boundaries. As defined by Joustra, de Jong and Engelaer "*The Circular Economy is an answer to the current linear economic system that can best be characterized as "take-make-dispose" and often referred to as a "Cradle to Grave". The circular approach is: "take-make-use-reuse-remake-reuse-…". It is based on continuity in the use of materials and business models that support a new system of value creation*" (Joustra, de Jong & Engelaer, 2013. p.9). It is an economic system that operates within the ecological barriers of our planet and in this sense may be seen as the desired future state from the perspective of resource use.

One of the most commonly used representations of circular economy, shown in Figure 3.1 below, was created by the Ellen MacArthur Foundation in collaboration with McKinsey. This representation shows how technical and biological material cycles are distinguished from each other (Ellen MacArthur Foundation, 2017). In accordance with this representation, Roos (2014) explains the circular economy as "*... a generic term for an industrial economy that is, by design or intention, restorative and in which material flows are of two types, biological nutrients, designed to re-enter the biosphere safely, and technical nutrients, which are designed to circulate at high quality without entering the biosphere*" (Roos, 2014. p. 254). Resources are here seen as temporary parts of a product or a service that are made available again after end of use.

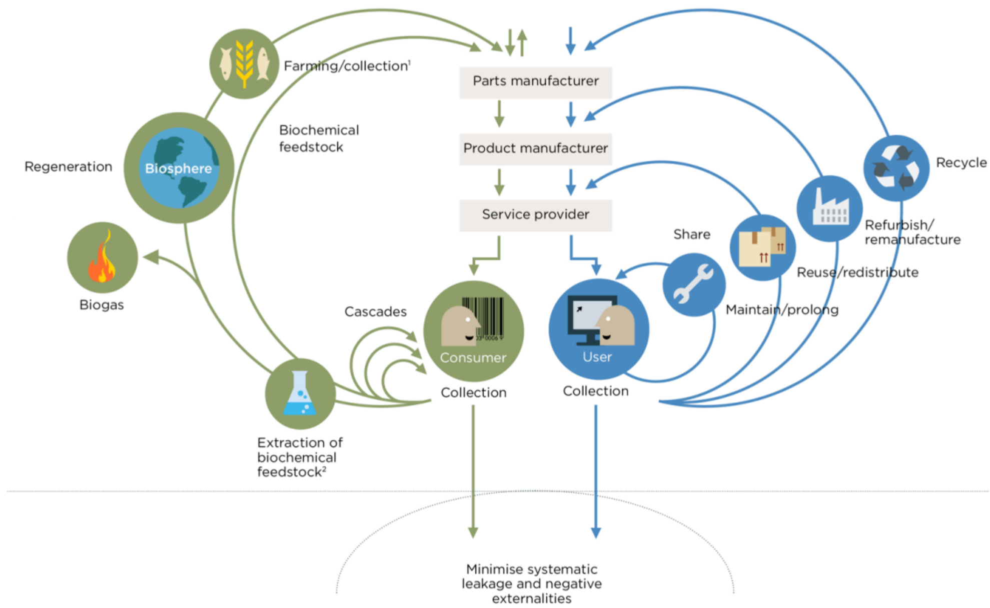

Figure 3.1 - System diagram of a circular economy (Ellen MacArthur Foundation, 2017)

One of the principles of circular economy is systems thinking. Being able to understand how different parts influence the whole and the influence of the whole on the parts is crucial within these kinds of sustainability transitions (Ellen MacArthur Foundation, 2013). This is important because the context in which the economy is embedded is built up by systems (Webster, 2013). Thinking in systems when working with circular economy, then, simply adapts the economy to its context. Furthermore, the connections between parts and flows within the system are just as important as the parts themselves, and merely looking at the parts says very little about the system as a whole. As the goal of circular economy is to optimise the system as a whole, not the individual parts within it, the necessity for systems thinking become evident.

3.4 Urban Metabolism

One system level approach to understand how a city functions in terms of flows, and what possibilities there are to transform towards a more circular economy, is the concept of urban metabolism. It refers to thinking of a city as a living organism, where matter enters, transforms and most often eventually leaves the city. A city can be seen to have four essential metabolism flows; water, material, energy and nutrients (Kennedy, Cuddihy & Engel-Yan, 2007). In cities today, these flows are becoming increasingly complex due to large stocks and high exchange rate of flows. Cities are unique in their specific metabolism but a common trait is the linear flows where reuse and recycling are rare. Understanding metabolism and flows is a complex task and research about this subject is still in its early stages (Ferrão & Fernández, 2013). Even though practical use of urban metabolism is limited, potential is seen in how it can guide regions in understanding whether their metabolism is efficient and identify opportunities for improvement and target policies (Ferrão & Fernández, 2013). Moreover, it can be a useful way to become more proactive in material management (Hendriks et al. 2010).

3.5 Material Flow Accounting

One of the branches within urban metabolism research is Material Flow Accounting (MFA). MFA is an analytical method that depicts the material flows, transformed products, emissions and leaks within a system (dos Muchangos, Tokai & Hanashima, 2017). Such overviews may assist in planning and strategy making for efficient material use. MFA data on a national level is currently available and in use. However, little data is available on regional or city levels. There is significant value in also understanding the material flows on an urban level, since national accounting does not consider the individual preconditions and needs of cities and therefore may be misleading (Ferrão & Fernández, 2013). According to Binder (2007), region specific MFA data can be applied to: "*... derive measures for improving the regional or corporate management of materials, e.g., to optimize resource exploitation, consumption, and environmental protection within the constraints of the region or company…*", "*... set up monitoring programs to evaluate the effects of policy measures…*" or "*As a tool for the early recognition of the impact of different scenarios of socioeconomic development…*" (Binder, 2007. p. 1597).

3.6 The UMAn model

The UMAn model which is based on MFA, was developed to provide overviews of material flows on an urban scale (Rosado, Niza & Ferrão, 2014). The data in the model is derived through a top-down approach using national Eurostat data as well as regional trade statistics. For the metropolitan area of Gothenburg, the model accounts for data from 1996 to 2011. The fact that UMAn utilises regional statistics has been acknowledged by other researchers as an aspect that generates more holistic and inclusive overviews as opposed to models that merely utilise household or national level data (Goldstein et al., 2016). Models that do not take such consideration risk underestimating the sheer amount of resources that cities absorb and consume.

Using the model, it is possible to look into flows in terms of materials or approximately 1000 product types and get insights on different levels of detail about to what extent they are consumed and by whom in terms of economic sectors (Kalmykova & Rosado, 2015). Product types refer to groups of items belonging to a certain category. For instance, the product type furniture might include items such as chairs, tables, desks et cetera. All flows are measured in mass, hence the metric in focus is tonnes, which has been critiqued by Goldstein et al. (2016) as not providing any insight about environmental impacts. However, what they do acknowledge as a contribution is the information it gives about deleterious exchanges of resources between society and the ecosphere. Comparing the flow characteristics of different cities, the UMAn model can be used to assign urban metabolism profiles.

3.7 Visualising flows – Sankey diagrams

MFA models, including UMAn, contain vast amounts of information about material flows. A common and efficient method to visualise these flows is Sankey diagrams (Schmidt, 2008; Alemasoom et al., 2015), which are flow charts displaying quantitative data on resource flows. Positive attributes of Sankey diagrams are the possibilities to look at multiple and various time intervals (Cuba, 2015), seeing the overall performance of a complex system (Pi-Cheng, Kun-Hsing & Hwong-wen, 2017), understanding systems at different scales (Abdelalim, O'Brien & Shi, 2015) and gaining understanding of dominant flows. The width of the arrows in a Sankey diagram represents the quantity of the mass, energy or other metric in focus (LLNL, 2018) and the varying widths display the flow's relative magnitude (Abdelalim, O'Brien & Shi, 2015). There are also vertical "gates" through which the flows pass and disperse. In this way, Sankey diagrams visualise both the size and the direction of the flows within a system (Cuba, 2015). An example of a Sankey diagram can be seen in Figure 3.2 below.

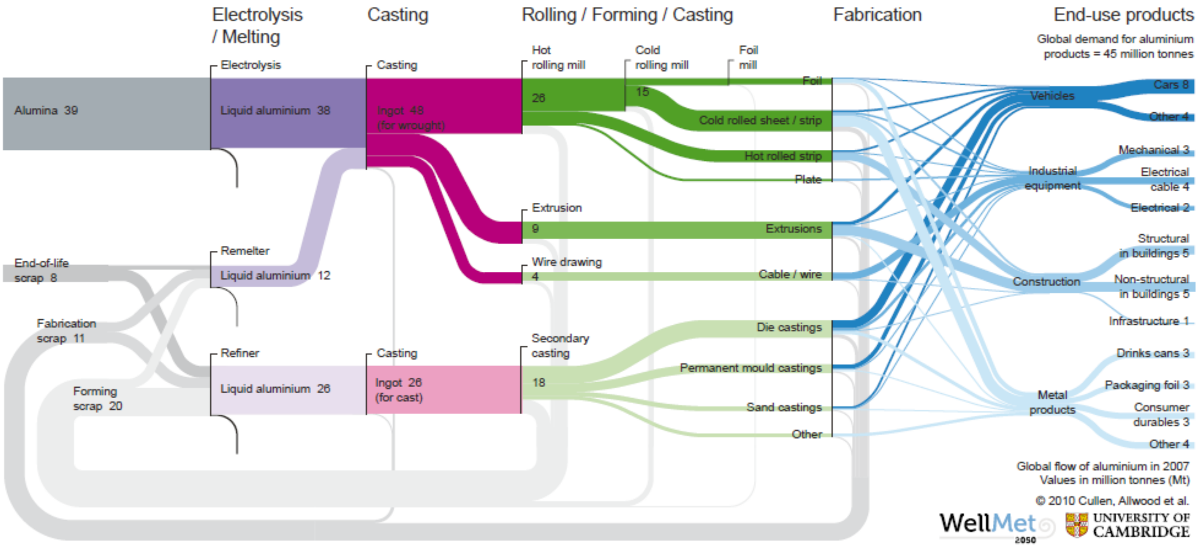

Figure 3.2 - A Sankey diagram displaying global flows of aluminium (Allwood et al., 2011. p. 6-7).

Sankey diagrams can be static or interactive (Alemasoom et al, 2015) and should preferably be clustered to reduce the number of diagrams required to present extensive data sets (Kothur et al., 2012). Animations can be used to maintain the viewer's mental map when exploring information (Alemasoom et al., 2015). Although Sankey diagrams provide a good method for visualising flows, they should be combined with other visualisation techniques, in terms of other charts or maps to enable explorations of spatial and abstract information simultaneously, as well as capturing multiple aspects in complex systems (Doantam Phan et al., 2005).

4. Methods and steps taken

The methods applied in this thesis contributed with information to multiple steps in the process. Therefore, in this chapter, the methods are first described briefly in more general terms with explanations of how they were applied, followed by a description of the steps taken in the project process and how the respective methods contributed to those steps. Figure 4.1 below displays the process and how it initially consisted of two investigation focuses; Circular Gothenburg and their needs and UMAn and its potential value. Those two focuses were then merged through a match between value and needs that set the focus for concept ideation and development. The figure also displays which methods contributed to the results of each step.

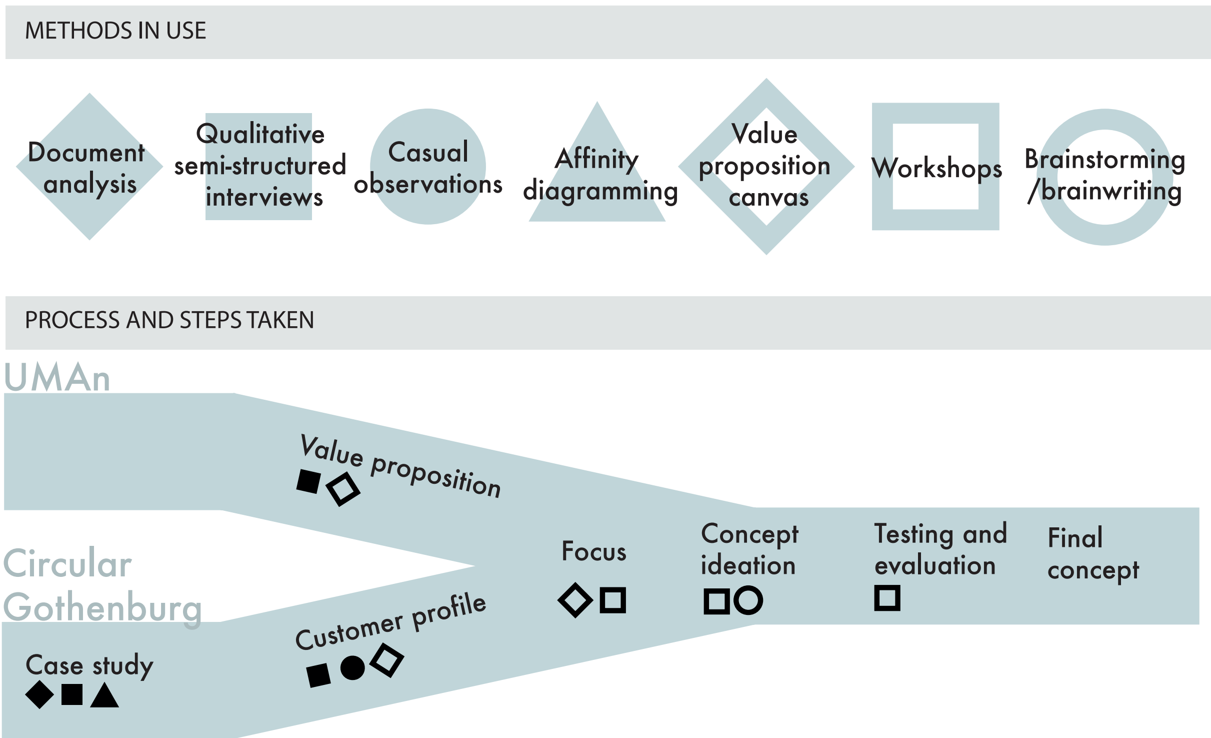

Figure 4.1 - *Overview of the methods in use and which of these were used in each step of the process. Own representation.*

4.1 Methods in use

The methods in use were selected specifically to fit the user centred approach adopted in this thesis and to translate the somewhat abstract concepts of needs and value into tangible suggestions for how to use the UMAn data. Multiple methods were applied to gather and analyse data, find focus for the concept development and iterate concepts in collaboration with Circular Gothenburg and the UMAn research team.

4.1.1 Document analysis

Document analysis provides a systematic way for analysing and reviewing literature and is commonly applied to triangulate research data (Bowen, 2009). For this purpose, it was used in combination with data from interviews, observations and workshops. Separate analyses were done for Circular Gothenburg and the UMAn model respectively. Documents in focus for the Circular Gothenburg analysis were regulatory documents, such as the climate strategic programme, the environmental programme and the budget of the municipality as well as previous applications for project funding and project descriptions. Documents in focus for the UMAn model analysis were articles citing the work published by the UMAn research team.

4.1.2 Qualitative, semi-structured interviews

Qualitative interviews were held to collect information about the two research focuses; the needs of Circular Gothenburg and the value of the UMAn model. The interviews were semi-structured, containing a script of question that allowed for flexibility and broad exploration of the two areas (Hanington & Martin, 2012). To view the scripts for each interview, please go to Appendix 2-3. Process and project leaders on both strategic and operative levels of Circular Gothenburg were selected as interviewees, as well as the project initiator. To get different perspectives on the value of UMAn, four people currently involved in the development of the model were interviewed. All interviewees and their respective role can be viewed in Table 4.1. All interviews were documented using audio recordings and key interviews were transcribed. Interview transcripts are not part of this report but may be received on request.

Table 4.1 *Interviewees and their roles.*

Interviewee	Role
	Circular Gothenburg
C1	Initiator of Circular Gothenburg
C2	Process leader of Circular Gothenburg
C3	Project leader of sub-project *Decreasing building and demolition waste*
C4	Project coordinator of sub-project *Reuse of furniture in public offices*
	UMAn
U1	Lead developer
U2	Previous co-developer
U3	Co-developer focusing on accounting for flows within multiple cities
U4	Co-developer focusing on connecting UMAn to Life Cycle Assessment

4.1.3 Casual observations

Casual, also known as semi-structured, observations (Hanington & Martin, 2012) were used to gather baseline information about the context in which the UMAn model would potentially be used. This method is typically applied to gain tacit insights about procedures. Two workshops, held within the project “Reuse of furniture for public offices”, as well as a meeting between the project coordinator of this project and an external actor, were attended.

4.1.4 Affinity Diagramming

Affinity diagramming was applied as an analysis method to process researched material. As the name suggests, this method is used to cluster information based on affinity, i.e. based on similarities in problems, issues, intents, needs et cetera that appear in the material (Hanington & Martin, 2012). In this way, different themes emerge. Two separate diagrams were made, one exploring the material about Circular Gothenburg and one the material about the UMAn model. The clustering was done on two levels, with headings and subheadings, to break large themes down into more manageable groupings, while still displaying the relations between those groupings. The sorted material was then used as support for setting the direction for the concept development.

4.1.5 Value proposition canvas

Material from all interviews was analysed using the framework of the *Value proposition canvas* (Osterwalder et al., 2014). As shown in Figure 4.2, the value proposition canvas consists of two parts, the *Customer profile,* which provides a detailed description of the customer segment in focus, and the *Value map,* which describes the value proposition of a specific business model. The customer profile breaks down the customer segment into three topics; *Gains*, *Pains* and *Jobs*. Gains describe benefits and positive outcomes that the customer is seeking, Pains the aspects that the customer is struggling with and Jobs what the customers is striving to achieve. The value map includes three headings of *Gain creators*, *Pain relievers* and *Products and services*. Gain creators describe aspects of the value proposition that aims to meet the needs of the customer, so called customer gains. Pain relievers describe how the product or service in the business model addresses the pains that the customers experience. Finally, the Products and Services simply list what is offered through the business model.

The customer jobs typically entail a set of gains that the customer wishes to achieve as well as pains hindering them from doing so. Similarly, the products and services of the value map lead to certain gain creators and pain relievers. This framework was specifically used to map the needs of Circular Gothenburg and the value proposition of the UMAn model, and to see where matches between the two could be found.

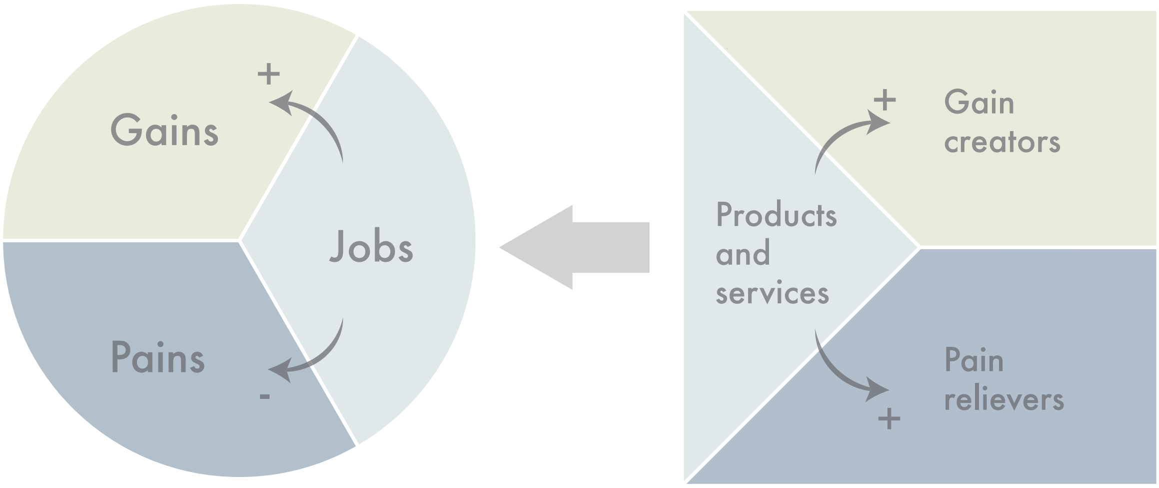

Figure 4.2 - The Value proposition canvas, with Customer profile to the left and Value map to the right. Own representation based on Osterwalder et al., (2014).

4.1.6 Workshops

Workshops were used to verify, iterate, prioritise, ideate and evaluate results. Altogether, three workshops were held with participants that had previously taken part in interviews. The workshops had various purposes, and a summary of participants and the purpose of each workshop can be seen in Table 4.2 below. All workshops included a part where created results were presented and discussed to gather feedback. Visual aid was used to facilitate the discussions, and participants were asked to co-create by adding, reformulating, rearranging and removing aspects. To view the plans for each workshop, please go to Appendix 4-6.

Table 4.2 *Participants and purpose of the workshops.*

Workshop	Participants	Purpose
1	C2, C3	Verify, iterate and prioritise Customer profile and Value map
2	U1, U3, U4	Ideate on possible concepts and narrow down the scope of concept development
3	C2, C3, C4, U1, U4	Evaluate and iterate ideated and visualised concepts

4.1.7 Brainstorming/Brainwriting

As described by Wilson (2013), brainstorming is an idea generation method governed by three distinct principles. Firstly, critique or judgement is strictly forbidden. Secondly, quantity in ideas is prioritised over quality. Thirdly, all participants should encourage new, creative and wild ideas. While in a brainstorming session, participants present and discuss ideas out loud, a brainwriting session begins with participants individually writing down ideas to then move into presentations and discussions. Semi-structured brainstorming and brainwriting sessions were carried out within the thesis team to generate ideas for functions based on the UMAn data. The sessions were largely based on the matches between the needs of Circular Gothenburg and the value proposition of the UMAn model, and were documented using post-its, whiteboards and digital charts.

4.2 The steps in the project process

This chapter presents, in greater detail, the steps taken in the project process and how each of the methods presented in the previous chapter was incorporated. The steps follow the chronological order in which they were carried out and results from these steps are later on presented in this same order.

4.2.1 Understanding the case study

Since Circular Gothenburg act as case study in this thesis, the initial step in the project process was focused on becoming familiar with their work, the context in which the UMAn model would potentially be used, and the people who would use it. Through interviews and observations, information about Circular Gothenburg's work processes in terms of what they do, but also how different individuals work and communicate, was gathered. Moreover, influential factors that steer their processes, existing support in decision-making processes and goals for the different sub-projects were investigated. This information was then compared with results from the analysis of regulatory documents, which displayed how they *should* work in terms of which goals should be prioritised. Apart from getting a broad understanding of Circular Gothenburg, this step aimed to give initial insights into what role the UMAn model could play in their work.

4.2.2 Mapping the customer profile of Circular Gothenburg

One goal in this thesis is to give suggestions for how the UMAn model can be developed for more practical application and in that sense provide support for Circular Gothenburg. In order to do this, a user-centred approach was applied where the needs of Circular Gothenburg were put in focus. Information about those needs was mainly gathered through interviews and to some extent observations, and then transferred to the Customer profile in the Value proposition canvas. Each transcript from the interviews with Circular Gothenburg was scanned through and quotes that concerned the categories Jobs, Pains and Gains were extracted and transferred into the corresponding categories in the Customer profile. Figure 4.3 below shows the working model of the Customer profile. The different quotes under each category were then clustered into themes based on affinity, and described more comprehensively. Workshop 1 was used to verify and iterate the contents of the Customer profile by letting the participants rephrase, add and remove content to make it better fit their view of their own needs.

Figure 4.3 - The working model of the Customer profile.

4.2.3 Mapping the value proposition of the UMAn model

To understand the potential value that the UMAn model can, or potentially could, provide to Circular Gothenburg, a second mapping was done including the three aspects of the Value map. Quotes from interview transcripts with the UMAn research team were scanned, and relevant ones were extracted and colour coded depending on whether they belonged to the category Gain creators, Pain relievers or Products and services. Figure 4.4 below shows the working model of the Value map. Also in this mapping, quotes were clustered into themes and described more comprehensively.

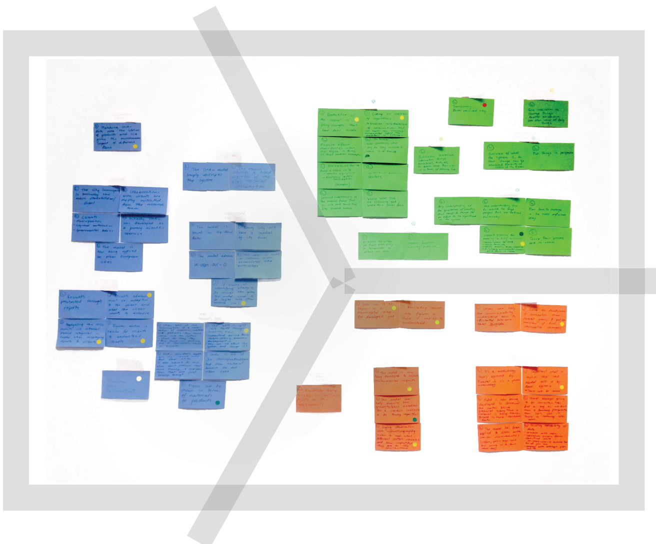

Figure 4.4 - The working model of the Value map.

4.2.4 Finding focus for concept development

Having mapped the customer profile and value proposition, a comparison between the two was made to find possible matches that could guide the concept development. Needs and values that to some extent correlated were extracted. The values were then categorised depending on their relevance for Circular Gothenburg while needs were categorised depending on the extent to which they could be met using the model in its current state of development. To limit the scope of concept ideation further, Workshop 1 was used to prioritise amongst these extracted aspects from the Value proposition canvas. Circular Gothenburg got to highlight the aspects from the Customer profile that they found most important as well as the aspects of the Value map that they found particularly interesting.

4.2.5 Concept ideation

With the matches between customer profile and value proposition as guidance, concept ideas were generated using Brainstorming and Brainwriting. These ideas were developed with two criteria in mind; that they should meet a need or interest from Circular Gothenburg and/or be feasible now, with further development of the UMAn model, or in the future. Both criteria did not necessarily need to be fulfilled as it was found important to initially display the potential value of UMAn regardless of whether there was an explicit interest from Circular Gothenburg. In Workshop 2, the participants from the UMAn research team were introduced to the different ideas and asked to assess when in time they could be feasible. For each idea, they were also asked to state what type of data that would be required, if and how the model would need to be developed and whether it would require new ways of working from the user's perspective. After the workshop, the components were visualised.

4.2.6 Testing and evaluating

In Workshop 3, which was a joint workshop with participants from both Circular Gothenburg and the UMAn research team, selected visualisations were displayed and evaluated. They were not based on real data in order to focus the feedback on the visualisations as such and not on whether the data and numbers were reasonable. Each was presented separately, followed by a discussion regarding relevance and intuitiveness. From these discussions, feedback on both the layout and characteristics of the visualisations, as well as their content, was extracted. This was then used as a basis for iteration.

4.2.7 Providing a final concept

By thorough analysis of the feedback from Workshop 3, a final concept was developed, taking into account requested alterations by adding, changing or removing components and information. Focus laid on suggesting relevant information to include when developing the model for a user, as well as specific ways of showing it. From this final concept, next steps in the development of UMAn could be identified and suggested.

5. Insights from case study on Circular Gothenburg

This chapter describes insights from the case study on Circular Gothenburg as a potential customer of the UMAn model data. The insights are based on interviews, document analysis and workshops and aim to provide a context for the analysis and results in chapter 6 and 7.

Circular Gothenburg is a three-year financed project initiated by Gothenburg municipality. It aims to facilitate and develop practises to use resources more efficiently within the municipality’s own organisation and to aid the citizens of Gothenburg in making resource efficient choices. The project was initiated by the department of Sustainable Waste and Water when they were appointed process leader of the goal to improve resource management within the municipality’s organisation. To investigate where to start and which resources to focus on, a pre-study was made to map out current waste streams. This pre-study served as a basis for what became the focus areas for Circular Gothenburg.

Circular Gothenburg aims to make the transition from a linear to a circular economy happen in practise. They aim to drive change, be a catalyst and provide an arena for meetings within circular development. Their focus is mainly on the municipality’s own operations, to increase reuse and prevent waste; the upper two steps in the waste hierarchy shown in Figure 5.1. However they aim to take a wider grip of the city’s resource use by also working towards the citizens. They further aim to take a holistic perspective on the circular processes that the municipality can affect.

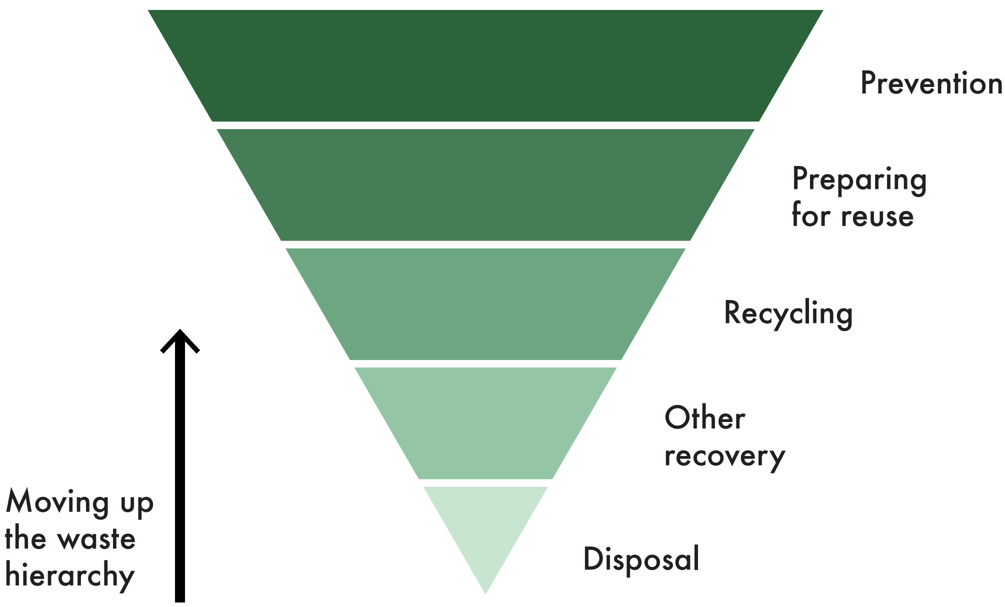

Figure 5.1 - EU:s waste hierarchy. Own representation based on European Union (2010).

Within Circular Gothenburg, there are several sub projects being run in parallel, two of which are described in more detail below. The five main focuses are (1) Circular business development, (2) Increased reuse and redesign of furniture in public offices, (3) Circular city planning, building and demolition, (4) Sharing initiatives in public places and (5) Circular neighbourhood services. They also offer support, both operative and strategic, if approached by external actors. Striving for an increased cooperation between actors in the city, they try to be a central actor for circular efforts. In this position, they take on the role of gaining and spreading information about circular efforts. The projects in Circular Gothenburg typically categorise within one or a few of the activities *Plan*, *Investigate*, *Test*, *Implement*, *Follow up* or *Evaluate* and can take the form of pre-studies, pilot tests or upscaling of successful solutions. The frames of Circular Gothenburg are mainly set by preconditions such as external financing, regulatory documents and decision boards, which they to some extent can affect through feeding back the results from pre-studies and pilot projects. Figure 5.2 below visualises the contents of Circular Gothenburg's current work and displays in which parts that external factors such as regulatory documents and financing or external actors affect the work.

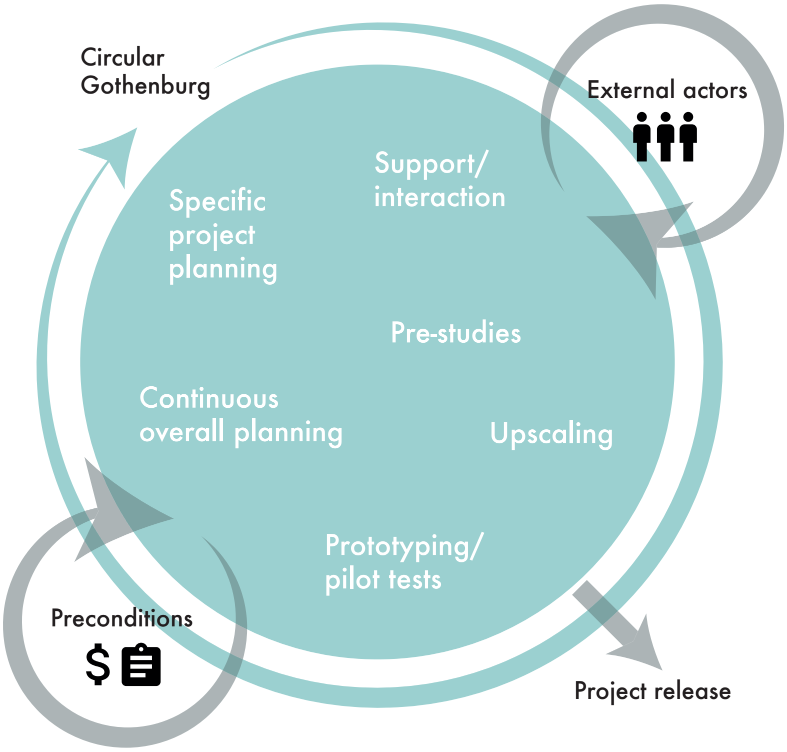

Figure 5.2 - Circular Gothenburg's current processes. Own representation.

One of the sub-projects within Circular Gothenburg focuses on increasing reuse of furniture in public offices. The goal is to identify barriers and thereafter come up with concrete suggestions for how to move beyond these barriers in order to make it easier for the municipal organisation to, when in need of new furniture, purchase reused ones. The project involves several actors from the municipality, interior design and architecture firms, and moving companies. An important part of the project is multi-stakeholder workshops, where barriers connected to reuse of furniture are discussed.

The second sub-project takes the form of a pre-study, focusing on decreasing building and demolition waste. The goal of decreasing these waste streams lay on a national level, and Circular Gothenburg currently investigates what role they could have in reaching it. They seek to develop an understanding of what is currently being done within the municipal organisation to decrease these wastes, what more that could be done, what barriers that are hindering change and which actors that need support and in what way. The investigation will result in an action plan with suggestions for further work.

5.1 Existing structures for planning and prioritising

Planning and prioritising is done in several steps in the different sub-projects of Circular Gothenburg. It is done before sub-projects are initiated to set goals and directions forward, continuously during the project processes to adapt to new information, and finally when feeding back information and results to administrations or funding agencies. However, the overarching planning and strategizing for the whole of Circular Gothenburg is currently not prioritised and hence, quite rough. This depends on the fact that the focus of Circular Gothenburg is to make things happen in practice and not stop at research. This strive for taking projects further, all the way to testing and implementation, means that little time is left for overarching planning activities.

Current prioritisations and focus areas mainly stem from regulatory documents and the responsibilities that the administrations in charge of Circular Gothenburg have been given by the City council and the Environment and climate committee. While some activities are prioritised for their environmental impacts, others are carried out because they have potential to influence social sustainability and can lead to attitudinal and behavioural changes which in turn may have positive impacts on the environment. Circular Gothenburg can to some extent impact those areas of responsibility by feeding back information from pre-studies and other projects and giving suggestions for new goals or possible future actions that may be accepted in revisions of the regulatory documents. The priorities for Circular Gothenburg are rather static as they have been stated in applications for funding. If they receive funding, they have to make sure the goals in the application are met. In this way, the project-based funding hinders dynamic planning. There is some space for own initiatives in the planning processes. If they are approached by other actors, within or outside the municipal organisation, that wishes to initiate collaboration, or if an interesting opportunity emerges within an ongoing collaboration, Circular Gothenburg has the possibility to engage in projects that lay beyond the focus areas stated in the regulatory documents and applications for funding. However, due to time limits, ongoing projects are typically prioritised before new ones.

6. Highlighted results from the design process

This chapter begins by presenting the customer profile and value proposition, followed by an analysis of where aspects within each match. The continuing sections describe how matches were translated into concepts, how these concepts were visualised and finally how the visualisations were received and evaluated by Circular Gothenburg and the UMAn research team.

6.1 The Value Proposition Canvas

The results from the Value proposition canvas are first split into separate presentations of the customer profile and value map and then analysed together in section 6.1.3.

6.1.1 The customer profile of Circular Gothenburg

The jobs, pains and gains identified for Circular Gothenburg are presented in Table 6.1.

Table 6.1 *Identified jobs, pains and gains*

Jobs	Pains	Gains
Plan & prioritise • Setting project goals • Setting project milestones • Setting measurable effect goals for projects	Too narrow input to strategy and planning work Time limits Unclear effect goals & milestones	Target efforts Effective action plans to reach environmental goals Confidence in decisions & direction
Scan the current state of an issue	Missing reliable, easy-to-use models	(All gains listed in this column)
Collaborations across borders • Identify and engage key stakeholders	Difficult to divide roles & responsibilities	Reach a bigger mass Effective action plans to reach environmental goals
Catalyse change • Be a role model	Difficult to estimate the effect of a project	Engage funding sources Reach a bigger mass

Amongst the jobs of Circular Gothenburg is for instance planning and prioritising, both for the project in large as well as the different sub-projects. This job is currently made difficult due to the pain of time limits, making little space for planning activities. Moreover, the information input to planning is limited and would benefit from more diverse sources. Despite this, the overall project goals, which are part of the results from the planning process, are perceived as clear and well defined. What are lacking are specified milestones and measurable effect goals. Gains that are sought in relation to this job is to more efficiently target efforts, create more effective action plans to reach the environmental goals and to gain greater confidence in the decisions and directions that are set in the planning.

A job connected to planning is scanning the current state of the issues that Circular Gothenburg address. Having a good overview of these issues is crucial in order to reach all of the identified gains. This requires access to sufficient and relevant information which could be increased by reliable and easy-to-use data models. The information that is currently used for this job is to a large extent gathered by carrying out another one; the job of collaborating with other actors across borders. This in turn requires identification and engagement of key stakeholders. Cross border collaborations aim to achieve the gains of effective actions plans based on the knowledge of multiple actors as well as reaching a bigger mass.

Another job within Circular Gothenburg is to catalyse change by working with multiple actors and moving from research to action. In this capacity, they strive to be a role model within resource use, using the force of the municipal organisation to create change. A driving force connected to this job is to create social and environmental change by making sure ongoing projects are completed and by keeping as many projects as possible alive. Through this job, they aim to achieve the gains of reaching bigger masses and engaging funding sources. However, because of the difficulties in estimating, and thereby showing, the effects of the projects they carry out, it can be hard to motivate why the project should receive funding or why others should engage.

Amongst these jobs, pains and gains, aspects highlighted as particularly important are; being able to set effect goals so that more clearly defined milestones can be derived, reaching a big mass for large effect, working with issues the municipality have possibility to influence, moving from research to action and involving several actors across borders.

6.1.2 The value proposition of the UMAn model

Identified Products and Services, Pain relievers and Gain creators of the UMAn model are presented in Table 6.2.

Table 6.2 *Identified products and services, pain relievers and gain creators*

Products and services	Pain relievers	Gain creators
Overviews of flows on city-level • Communicate data through graphs and figures	Knowing where to start Understand trends in consumption behaviours	Region specific information Effective planning and prioritisation for circularity Create confidence in decisions & directions Common framework for material flows in the city
Analysed data for specific queries	Quantify efforts	Simulate and evaluate efforts Understand interactions between regions
Connect the model with other information • Combining model with LCA data	Estimate environmental impact from a wider perspective	Motivation and inspiration Effective planning and prioritisation for circularity

The main product of UMAn is overviews of flows on a city-level which are currently communicated through charts and figures, presented in presentation slides or in reports. Receiving region specific data is an important gain creator, as stated previously, since the flow characteristics of a region may not correlate with that of the nation. Region specific data then constitutes a more relevant basis for local policy making. Overviews of flows may further provide the gain creator of effective planning and prioritisation for circularity by relieving the pain of not knowing where to start, i.e. what flows to target, and by giving an understanding of trends in consumption behaviours. This may in turn lead to the gain creator of greater confidence in decisions and directions. If used by several actors, overviews may also provide the gain creator of a common framework for material flows in the city.

Another product of UMAn is analysed data for specific queries. This creates gain for instance by enabling simulation and evaluation of the effects of efforts and by providing an understanding of the interdependencies between regions. It may further relieve pains connected to effect goals by quantifying how extensive an effort needs to be to create a certain effect on the larger system.

Connecting the model with other information is required to achieve the pain reliever of estimating environmental impacts from a wide perspective. More specifically, the model needs to be combined with Life Cycle Assessment (LCA) data. If this would be done at greater scale, the model could create an understanding for trade-offs between various environmental aspects such as; climate change, acidification, eutrophication, photochemical ozone formation and resource utilisation, taking place when a specific flow is exchanged for another. It would also be able to show environmental effects of different efforts which could lead to the gain creators of motivating and inspiring change and of effective planning and prioritisation for circularity.

6.1.3 Matches between customer profile and value proposition

Figure 6.1 and 6.2 below show aspects from the Customer profile and Value map that match or could match in the situation of further development of the UMAn model. Aspects concerning time limits, which cannot be solved using data from the model, are here on excluded. The aspects in the figures are colour coded using green, yellow and orange dots. A green dot is given to aspects that can be realised using the model in its current state of development. UMAn could for instance, based on existing data, contribute to the job to *scan the current state of an issue* by providing region specific information on flows, or relieve the pain of having *too narrow input to strategy- and planning work* by adding the perspective of urban metabolism. A yellow dot is given to aspects that the model would be able to realise with some further development. For example, for the gain to *target efforts* the model could, if combined with LCA, provide information about environmentally critical flows. An orange dot symbolises aspects where there is potential for application of UMAn, however not in the near future. The gain creator to s*timulate & evaluate efforts* is one such possibility where if it was to be realised now or in near future, simulations would entail too much uncertainty to be used practically.

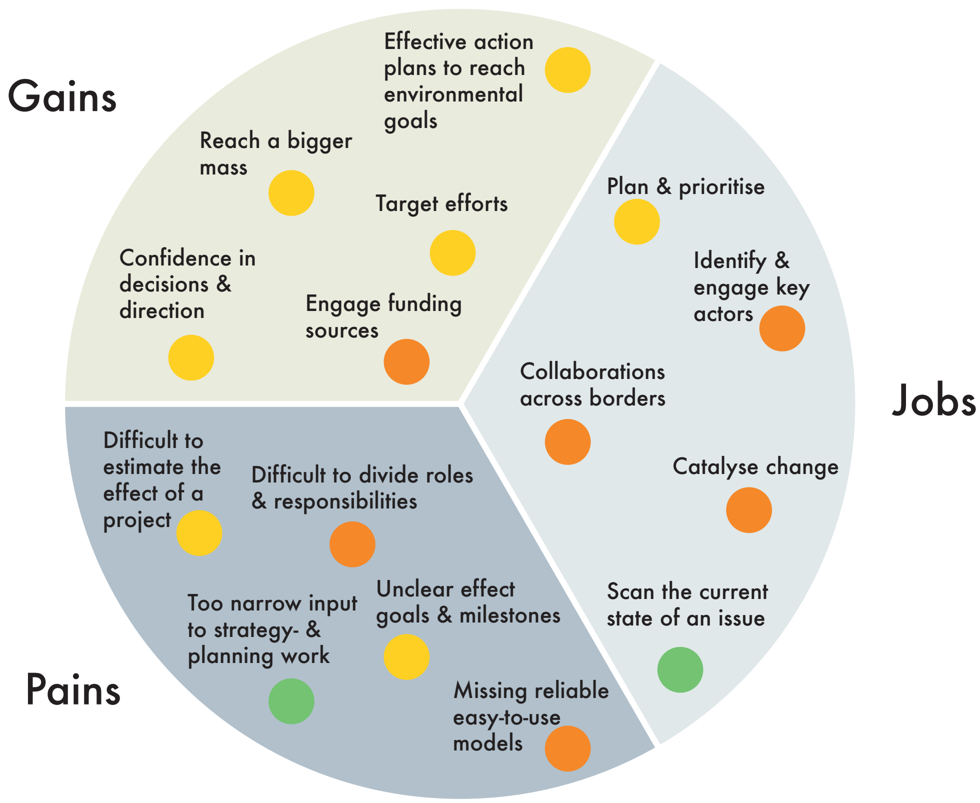

Figure 6.1 - Aspects from the customer profile, colour coded according to whether they are feasible now (green), with development of UMAn (yellow) or in the far future (orange).

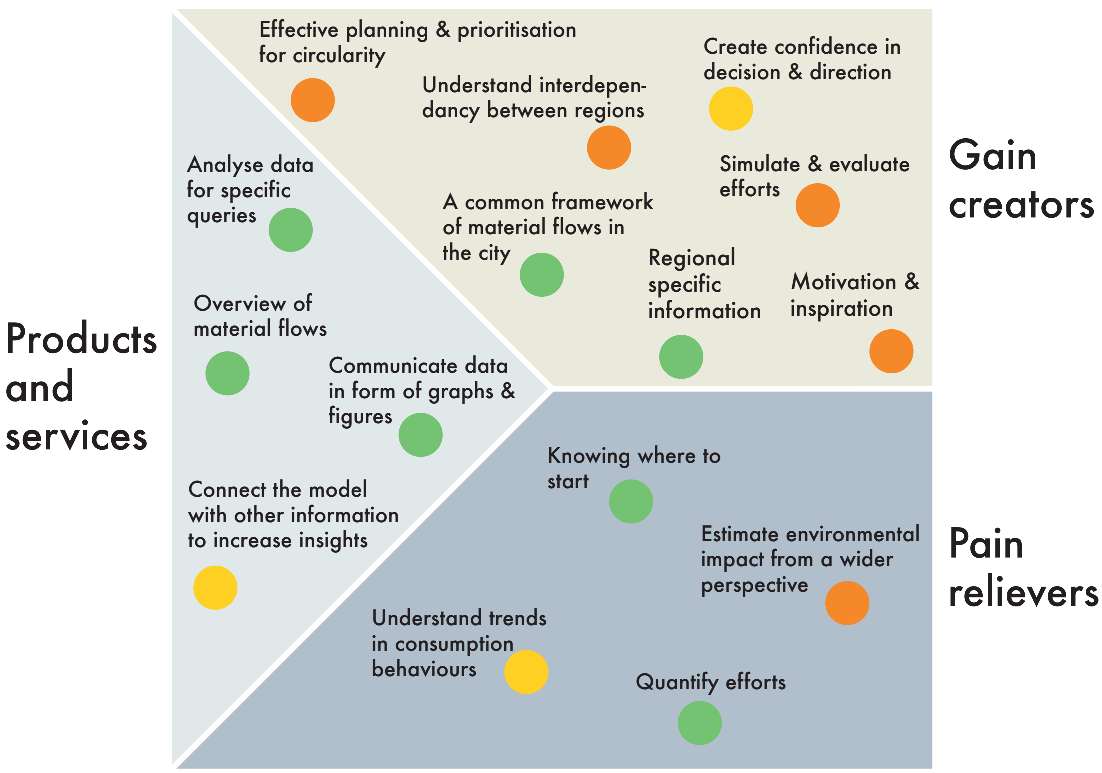

Figure 6.2 - Aspects from the value map, colour coded according to whether they are feasible now (green), with development of UMAn (yellow) or in the far future (orange).

Aspects of the model found particularly interesting for Circular Gothenburg at this stage were for instance the pain reliever *quantifying efforts* and the gain creator *simulating & evaluating efforts*. These aspects received attention because of their potential in contributing to setting clearer effect goals and achieving more effective action plans. Having seen the value map, Circular Gothenburg also expressed a wish to gain information about critical flows and actors driving this critical consumption, which puts emphasis on the product *overview of material flows* and the pain relievers *understanding trends in consumption behaviour* and *estimating environmental impact from a wider perspective*. Such knowledge could further aid in the job *identify & engage key actors* and relieve the pains of it being *difficult to divide roles & responsibilities* and having *too narrow input to strategy- and planning work*.

In addition, the need for understanding their own possibilities to impact flows and the efforts required to do so was emphasised. Moreover, possibilities to filter information about flows to get more detailed insights would be more valuable than merely having an overview over the flows of the entire city. For instance, since the main focus of Circular Gothenburg is the municipal organisation itself, they would like to be able to see their own consumption. There is particular interest in gaining a better understanding of the flows of food, plastics and bulky waste which are three important material streams that the municipality is targeting. These needs relate specifically to the product of being able to *analyse data for specific queries.*

Concerning how data should be delivered and presented, Circular Gothenburg emphasised the need for clear language, availability, transparency and high usability. They have little interest in analysing data themselves, and so, data should preferably be analysed and ready to act upon when they receive it. Due to time limits in the project, there is incentive for enabling Circular Gothenburg to access the UMAn data independent of the research team which in turn would require automated ways of validating and analysing data.

6.2 Concept development based on Value proposition canvas

Based on the need for available and accessible data, a concept was formed to make UMAn available to users through a software. Such a software could include multiple components, based on the different possibilities of the UMAn model and could be complemented with new components as the model develops. The development of software components was divided into three different phases depending on when in time different components would be feasible. Although all components could be part of the same software, they were visualised and tested separately to facilitate an evaluation of their respective relevance. Important to note is that the two initial sections of this subchapter are based on the authors own understanding of the UMAn model. The evaluation presented in the third section of the chapter is based on the inputs from workshop 2 and 3.

6.2.1 Ideation of software components in three phases

Because of a distinction between the development, and thereby time, required to realise different possibilities of the UMAn model, ideas for software components were generated in three phases; *Now*, *With development of UMAn* and *Long-term possibilities*. These phases made it possible to display the potential of UMAn without being restricted by its current limitations. The development was primarily guided by matches in the Value proposition canvas. However, some were based merely on an interest from Circular Gothenburg or possibility within UMAn. All components and the respective aspects from the Value proposition canvas that they concern can be viewed in Table 6.3.

Table 6.3 *Software components*

Component	Aspects from Customer profile	Aspects from Value map
	Now	
Overview of flows	Need for scanning and understanding the current state of issues they address, having confidence in decisions and getting diverse input to strategy work.	Providing overviews of material and product flows on an urban level.
Set rough effect goals	Need for clarified effect goals and milestones.	Possibility to view the effect on the overall system from a specific intervention.
Display environmental impacts of flows	Need for understanding environmental impacts and important targets.	Possibility to view the quantities of flows in the city combined with LCA data.
Overview of the municipality's consumption	Circular Gothenburg's emphasis on making the municipal organisation more circular	Possibility to view actors tied to certain flows
	With development of UMAn	
Simulation and/or evaluation of efforts	Need for efficient action plans and prioritisations, as well as understanding effects of efforts	Possibility to test and evaluate the effect of new policies.
Displaying regional/national interrelations	-	Possibility to display dependencies on certain areas for import or export and interactions between regions
Displaying actors connected to critical flows	Need to collaborate with other actors and divide responsibility.	Possibility to see who consumes certain flows.
Possibilities to influence	Interest in understanding their impact and influence flows.	Possibility to see who is tied to certain flows.
	Long-term possibilities	
Showing progress in relation to overall goals	Interest to know how far different projects take them on the way towards larger, overarching goals	-

6.2.2 Prototyping first iteration of software components

To make ideated components more tangible and test them towards Circular Gothenburg and the UMAn research team, they were visualised and described using visual aids. Those found within the *Now*-level in Table 6.3 above were prioritised before those in *Long-term possibilities*. The visualisation presented in Figure 6.3 displays overviews of flows. Each flow is separated through colour coding, using transparent colours to make it easier to follow specific fractions. All flows move through a set of "gates". The first set concerns origin and displays the distribution between imported and locally extracted materials or products. The second set displays the distribution of flows between economic sectors. In some cases, fractions of a flow will be transformed within the city before being consumed, which is shown through the separation of primary and secondary economic sector. The last set shows which parts of flows that remain in the area and which parts are exported. Mouse overs are used to provide additional information about the total mass of fractions as well as the percentage of renewability of the product or material that is being displayed.

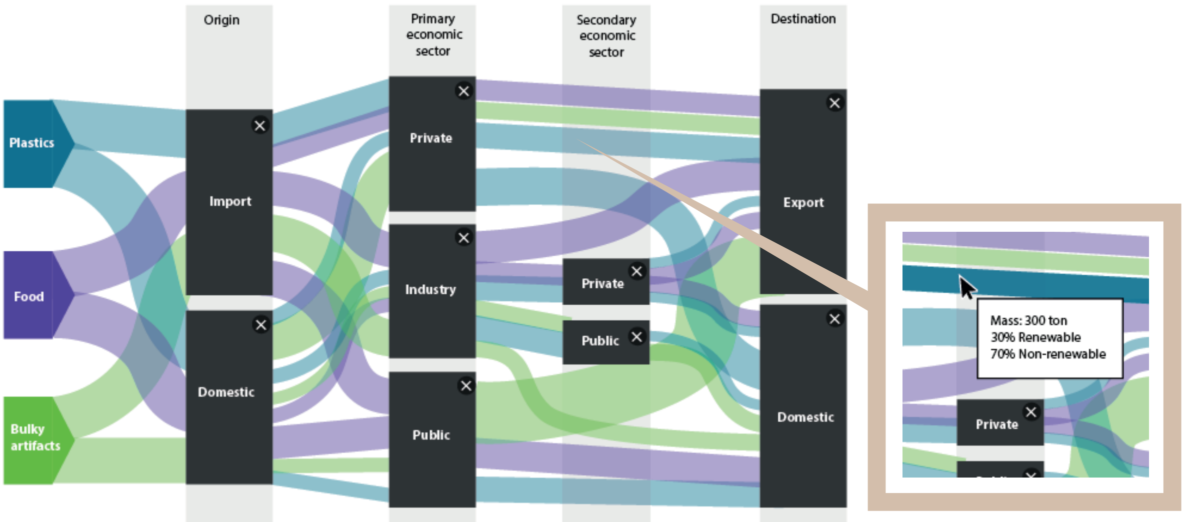

Figure 6.3 - Sankey diagram displaying overview of flows including mouse over showing the mass and percentage of renewability per fraction.

To display environmental impacts, the flows are colour coded in green, yellow or red as shown in Figure 6.4. Depending on the mass of a flow and the environmental impact of the specific material or product, the flow is coloured green if the total impact is low, yellow if it is medium and red if it is high. In this view, mouse overs provide information on total mass, percentage of renewability and the environmental impact of the specific material or product.

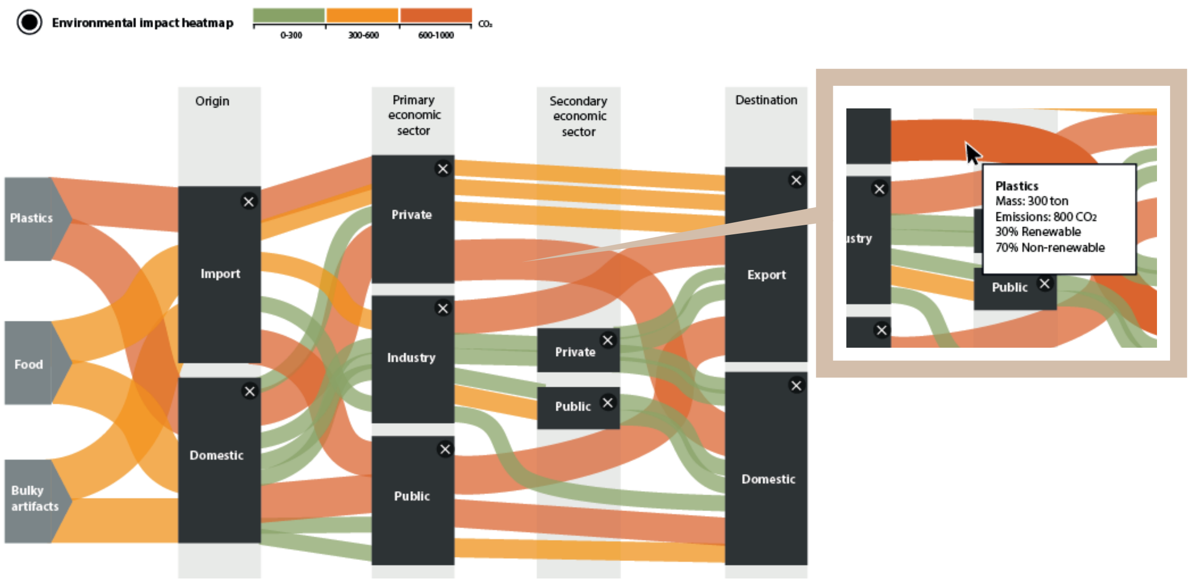

Figure 6.4 - Sankey diagram displaying environmental impacts of flows

Simulating and evaluating efforts is largely an exercise of playing around with numbers, which is why this component is not visualised as a chart but rather describes what can be done in terms of inputs and outputs. If for instance, as shown in Figure 6.5 below, Circular Gothenburg would have a goal for emission reduction on 30% and know which flows to target, this chart allows them to test different reduction rates for different flows that combined will achieve the overall goal.

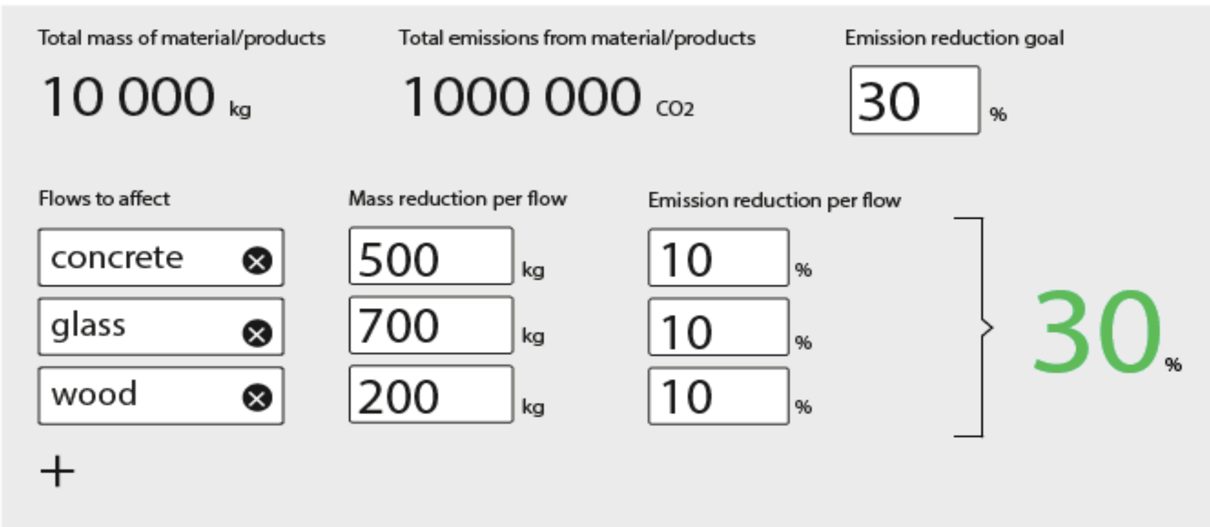

Figure 6.5 - Calculation chart for testing different scenarios

One purpose of making UMAn available through a software is to allow for zooming into different categories or flows to get more detailed information. One such zooming, shown in Figure 6.6 below, looks specifically into the flow of food.

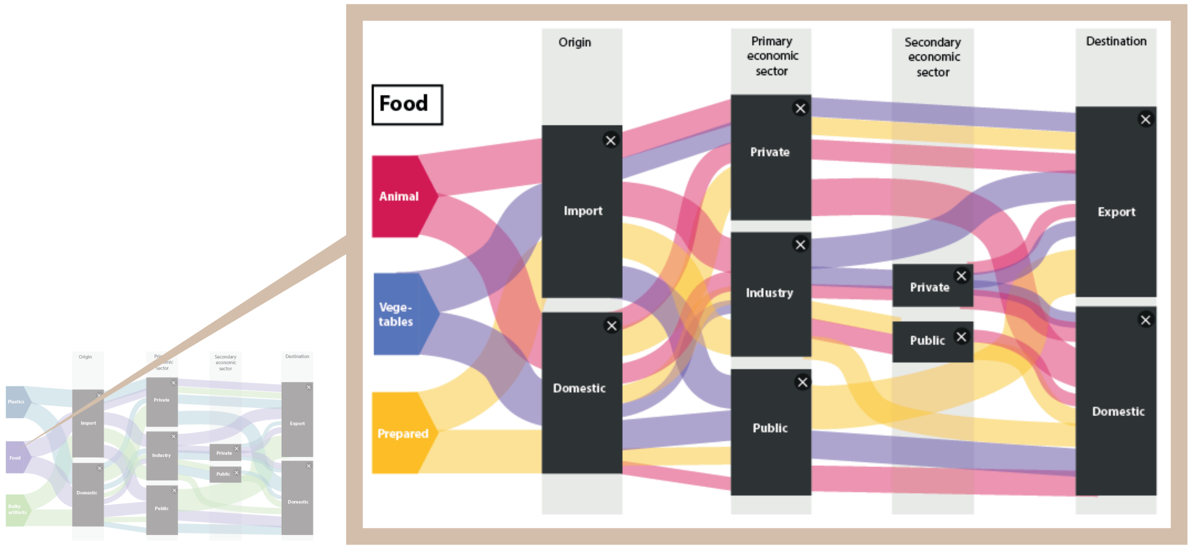

Figure 6.6 - Diagram zoomed into the flow of food.

Another relevant zooming, connected to the component displaying regional or national interrelations, is to look more in detail into the category “Import”. Figure 6.7 shows a hypothetical example of how flows are imported from other countries or regions in Sweden. A final example of a zooming looks closer into economic sectors to gain more information about actors connected to different flows. In this example, also shown in Figure 6.7, public sector is presented more in detail by displaying which flows that go into the administrative parts of the municipality, and which that are consumed through the services that the municipality provide.

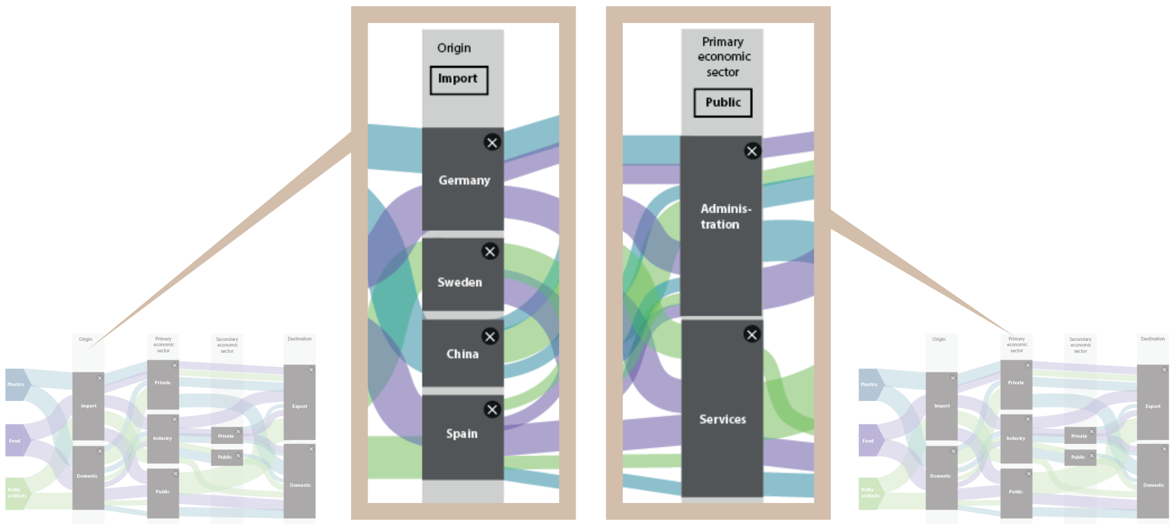

Figure 6.7 - Zoomed into the categories of import (left) and public sector (right).

6.2.3 Evaluating components and visualisations

Visualisations

During the third workshop, participants from both Circular Gothenburg and the UMAn research team gave feedback on the intuitiveness and content of the visualisations. The feedback about intuitiveness included for instance that the colours used to separate flows were too similar which made it difficult to follow a specific flow throughout. The combination of several flows in one diagram was valuable from the perspective of comparison. However, it made it difficult to follow the direction and dispersion of a specific flow, why a possibility to view flows separately was requested. Moreover, the naming and content of different gates through which materials and products flow, required greater clarification and explicitness.

The feedback about content included both general and specific remarks. Amongst the general feedback was for instance that the perspective of circularity, i.e. reuse, recycling et cetera, should be included visually in the diagram and not merely through mouse overs. It was also desired that both geographical system boundaries as well as time period would be stated explicitly. Phases in the flows, such as import, transformation, consumption and end-of-life, should be communicated more clearly. Finally, the design should take into account the times when this information needs to be displayed without the interactive software, as printed presentation material for example. Amongst the specific feedback was for instance that for the diagrams displaying environmental impacts of flows, the combination of mass and environmental impacts of specific materials or products may mislead the viewer. Because of the dispersion of flows, dividing the mass into smaller fractions, a flow that in total is red may be green when entering an economic sector. This in turn may lead a viewer from a specific economic sector to believe that their consumption of the flow need not be addressed. It was further desired to see the environmental impacts of a material or product separated from mass, as well as how much it contributes to different aspects of environmental impact, such as climate change or acidification.

Simulations, as presented in Figure 6.7, would most likely not be used by Circular Gothenburg, rather in higher instances within the municipal organisation. If such a component would be of use by themselves it should be formed rather as a service giving support for setting effect goals, not as a software exploring the issue independently. This was due to a concern of not having all of the pre-knowledge for drawing reliable conclusions. Neither was detailed information about imports interesting as origin has limited impact on the overall environmental impact of a material or product. Finally, the sub-categories found within the gate Public sector were not relevant and should instead display West Region Sweden (Västra Götalandsregionen) and Gothenburg municipality, this division of public sector would provide more valuable insights for them.

Feasibility

According to the UMAn research team, the timeline shown in Figure 6.8 was found more reasonable than the division of components presented earlier in Table 6.3. This timeline spans over five to ten years. All ideated components were perceived as doable although the suitability of the model decreases as the detail of queries increase.

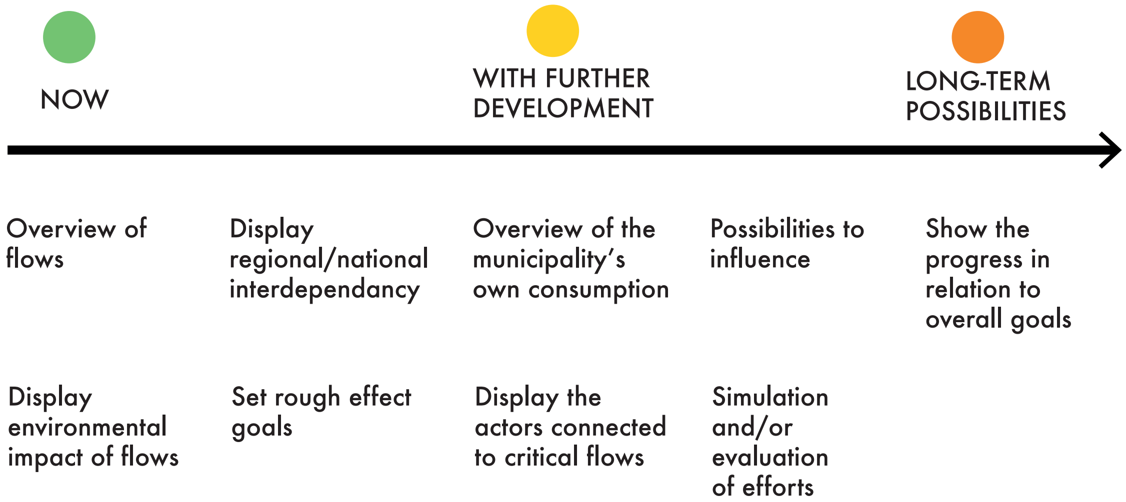

Figure 6.8 - Components mapped out on a timeline in relation to when they could be feasible.

Most components were placed within the phases *with further development* and *long-term possibilities* because additional data is required to provide them. Common for all components however is a need for more recent data on the flows within the city, i.e. data from after 2011. For components that are not feasible now, a few important developments need to take place before they can be provided. For instance, there is a need to complement already existing LCA data with further LCA profiles to be able to account for environmental impacts of more flows. Monitoring systems need to be put in place to analyse effects of different efforts, which can be fed back to provide more accurate simulations. Finally, the model needs to be complemented with data about consumption in order to state the actors tied to certain flows in greater detail. Related to this latter development is the barrier of accounting for material or product flows in consumption of services. If for instance Circular Gothenburg would purchase the service of construction of a new road, it is difficult to trace the specific materials and goods required to provide that service. Important to note is that while all concepts are doable, many will entail some levels of uncertainty, partly because of limitations in the data but also because societal development is difficult to predict since it is affected by multiple uncertain and often unexpected factors. Hence, for instance a simulation of a policy change may never provide exact answers.

7. Final outcome of design process

Described in this chapter is the final concept that has been iterated based on input from Workshop 3. The term *concept* is here on used to describe the final outcome in its entirety while the term *function* is used to describe its different components. The concept is initially described in general terms before its specific functions are described in detail. Thereafter suggestions for how to make use of the visualised concept in further development are presented.

The final concept is not restricted to the existing data within UMAn and should not be viewed as a finalised suggestion for how the data *should* be visualised. Rather, it is a suggestion for how it *could* be visualised that may serve as foundation for continued work.

7.1 Conceptual software based on the UMAn model

The final result of the design process is a conceptual software containing data from the UMAn model, complemented with LCA data. The software is meant to provide broader understanding of the city on a system level to support planning and strategizing for more circular product and material flows. It is designed to be used independently of the UMAn research team, providing possibilities for users to explore and gain insights from the data on their own. General functions are for instance the possibilities to filter the data in various ways, view data through charts and figures and get indicators on how to interpret the data. The following paragraphs explain the intended use of the software and which data is made available.

Initially, the user gets to specify what set of data to access. The filtering options which can be seen in Figure 7.1, include whether data should display mass of flows or their environmental impact, whether system boundaries should be on national or regional level, and whether flows should be displayed as final products or materials. The user can further choose which environmental impact type, geographical area and time frame that is of interest as well as how many and which product or material types to include. The product or material types represent groups of items belonging to a certain category as explain in chapter 3.6. For *Products/materials to include* and *Time frame*, the software can simultaneously display multiple ones. The function of filtering the data is necessary to comprehensively display the vast amounts of complex data in the software and to make it meaningful for the user. The specific filtering options presented here were proven relevant in Workshop 3.

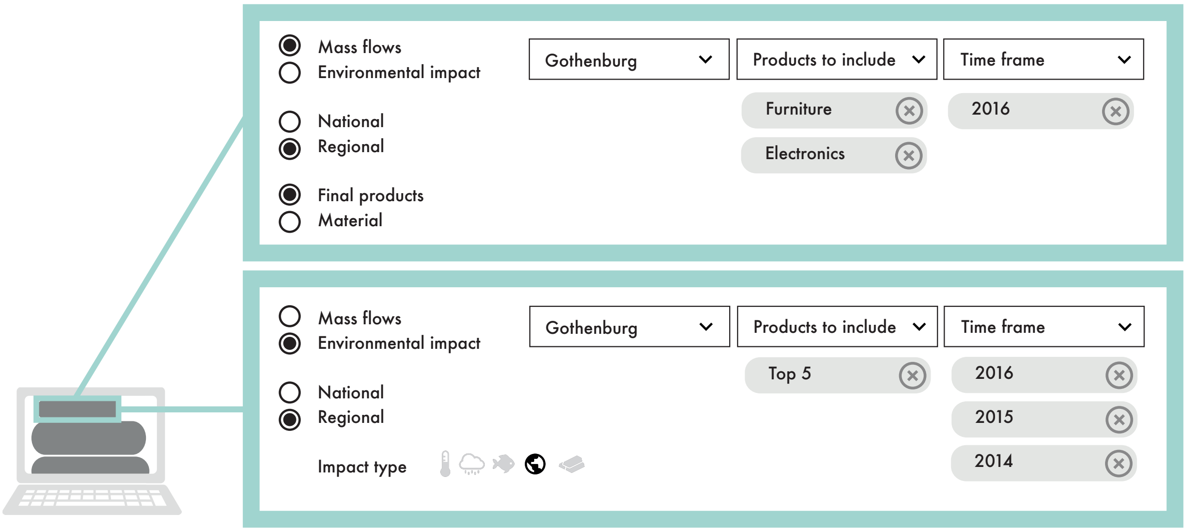

Figure 7.1 - Filtering options.

If filtering to show the mass flow of a certain product type, the user sees a Sankey diagram of that flow as shown in Figure 7.2. This diagram presents an overview of the total mass of the product flow in the selected geographical area; how much of this mass has been newly produced versus reused, what fractions go into consumption or stay in stock and which economic sectors consumes them. The diagram also displays what happens at end-of-life; how much becomes waste and how much goes back into the system through recovery. A function that has been added as a result of feedback in Workshop 3 is the possibility to save charts. This enables users to view flows separately while still having the possibility to compare them, however not in the same diagram. Saved charts can also be used for presentation purposes.

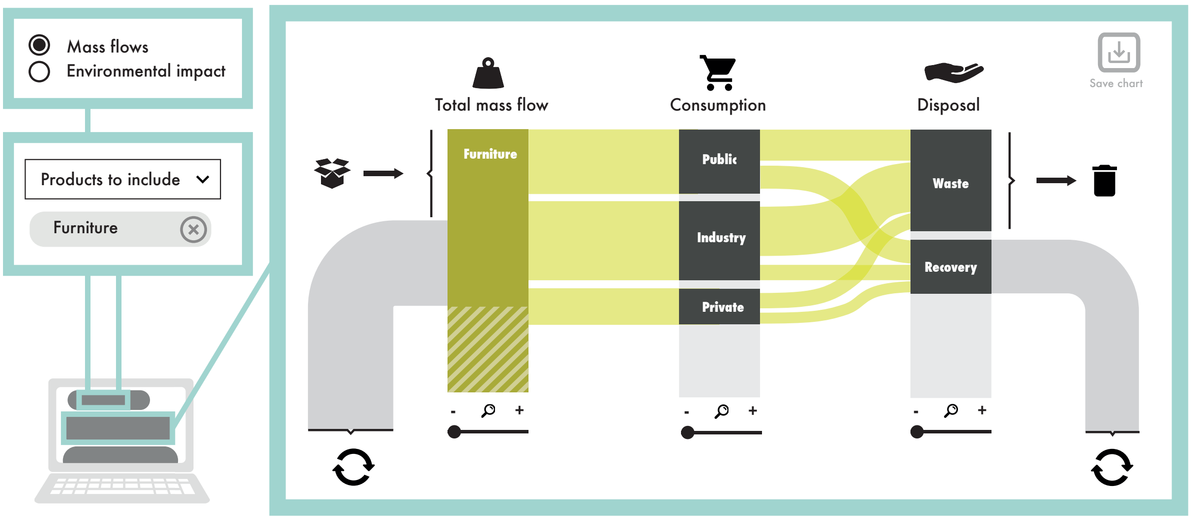

Figure 7.2 - Product flow example.

While the different gates are initially general, the user can zoom into each of them to reach greater detail. For instance, by clicking on *Public*, the user is presented to the sub-gates of Municipality, Regional County and Other as shown in Figure 7.3. This can provide insights about the municipalities own consumption and how it looks in relation to other actors within the public sector. The same can be done for *Industry*, which can give information about which business sectors are consuming certain products. This may in turn support the process of identifying actors to engage when aiming to reduce a certain product flow. Figure 7.3 also gives an example of zooming in to *Disposal* to review what type of recovery is being applied to a specific product flow. This information can be valuable in the municipality's strive to climb upwards the waste hierarchy.

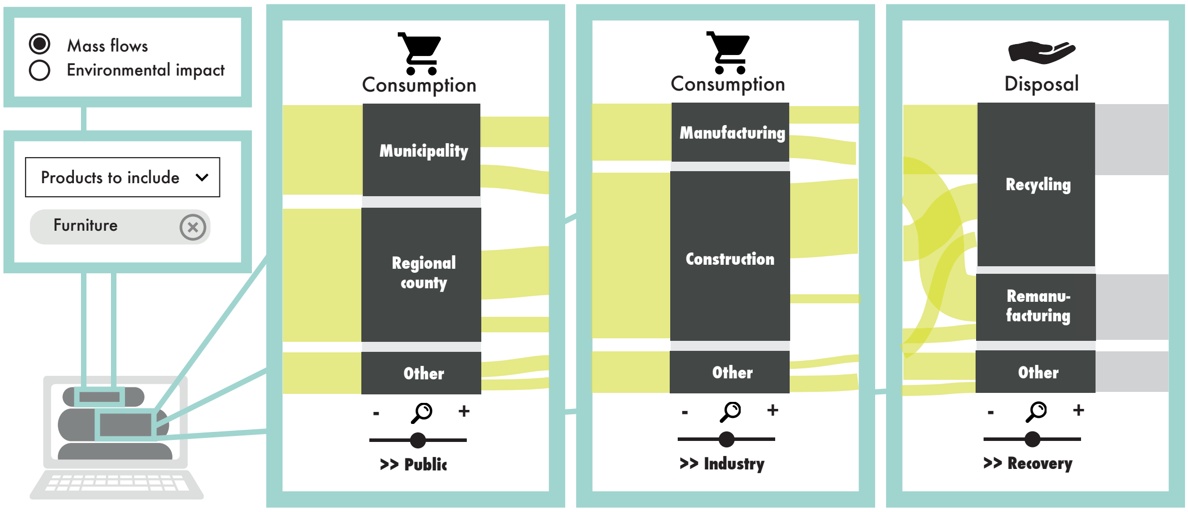

Figure 7.3 - Examples of zooming into categories.

As mentioned previously, it is possible to view multiple flows simultaneously as shown in the diagram in Figure 7.4. This makes it possible to compare different flows in the same diagram if the user finds that easier than comparing diagrams for several separate flows. The main changes that have been made to the Sankey diagrams, based on the feedback from Workshop 3, are the sets of gates that the flows go through have been reduced to only include consumption and disposal, gates have been refined for greater relevance, more contrasting colours are used for increased readability, symbols are used for eased information assimilation and the circularity aspect and saving function have been added.

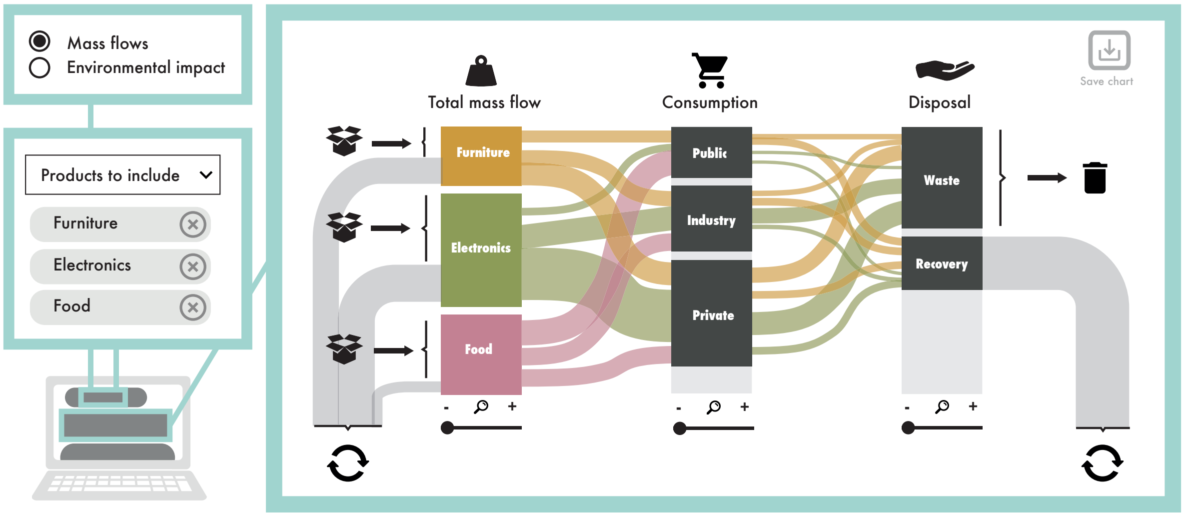

Figure 7.4 - Showing multiple product flows simultaneously.

As an addition to the mass flows, the user can access more detailed information through a flow analysis. Figure 7.5 shows information such as the percentage of circularity in the system, how the flow contributes to various aspects of environmental impact, consumption trends and environmentally significant products within the product type. The aim of this addition, apart from providing information on a more detailed level, is to support the user in analysing the data.

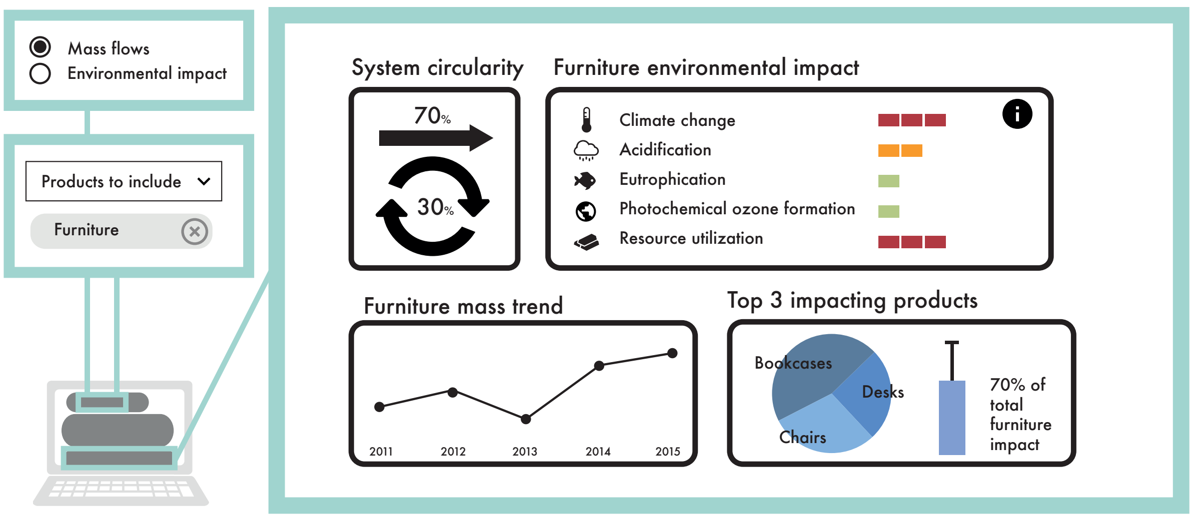

Figure 7.5 - Analysis connected to the mass flows.

Another possibility when viewing environmental impacts, other than looking at it from the perspective of a particular product or material mass as described earlier, is to look at it from the perspective of a specific aspect of environmental impacts. Hence, instead of initially choosing a specific mass flow to display, the user can choose between the aspect climate change, acidification, eutrophication, photochemical ozone formation and resource utilisation. The user can then choose to display the contribution to that aspect from specific products of choice, or from the top five most contributing products within the system. An example of this function is shown in Figure 7.6 where the user has chosen to display the top five product types contributing most to photochemical ozone formation. This information is provided through a pie chart showing the percentage each top five product type contributes with to the specific aspect of environmental impact. This is then put in relation to the influence of those top five product types on the specific aspect within the geographical area. As shown in the example, the top five product types account for 80% of the total contribution to photochemical ozone formation in the area. To better understand the magnitude of the specific aspect of environmental impact in the selected region, a benchmarking comparison complements the pie chart. This comparison displays the magnitude of the specific aspect in relation to the average of other areas; globally, nationally and regionally.

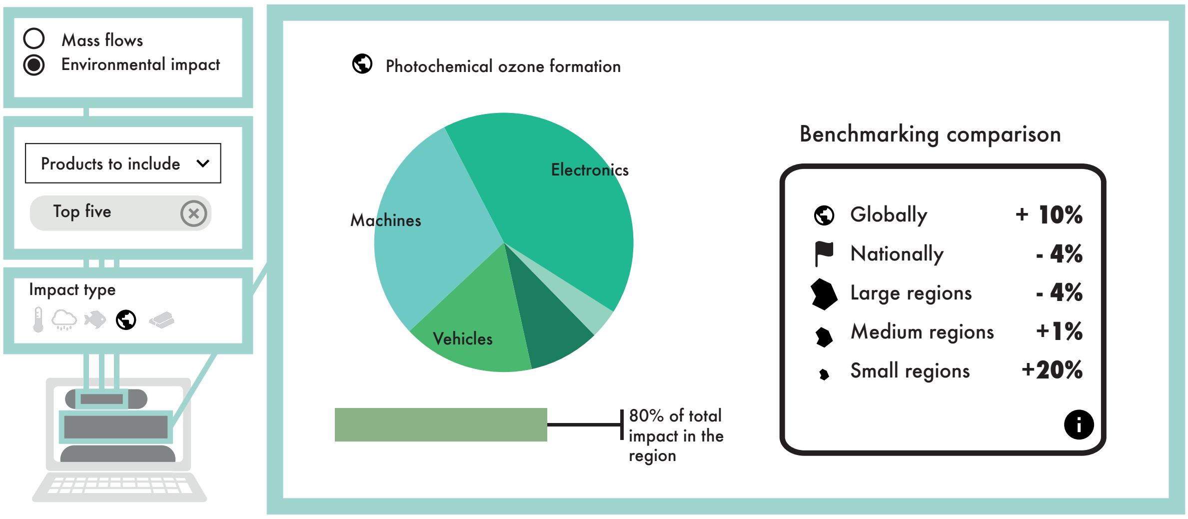

Figure 7.6 - Environmental impact indications.

7.2 Developing the concept in practice

Even though the conceptual software and its inherent functions are referred to as a final concept, it solely displays initial ideas on how a software using data from the UMAn model *could* be visualised for better comprehension and user friendliness. The visualisations aim to spur further ideas and development, and may provide a foundation for continued discussions that both Circular Gothenburg and the UMAn research team can relate to. The different functions in the concept still require different phases of model development, and thereby time, to be realised. The suggestion is to initiate software development based on existing data and add functionality as the model evolves. The best way to make use of the material would be to use it as foundation for further iterations in collaboration with potential users. The final concept aims to display the UMAn data in a relevant, simple and intuitive way. However, an evaluation of whether this aim has been met is yet to be made. Changes to the concept should continually be tested to make sure they result in a truly desired product.

Moving further with this concept, several aspects required to realise it are already in place, such as data on the masses of material and product flows, consumption trends over several years, groupings of data into different product or material types enabling some filtering options, data that can provide a rough idea of the circularity of flows, environmental impact of some product types and mappings of the metabolism of three regions in Sweden, enabling comparisons between them. For the software to include all functions from the final concept, a few crucial model developments need to take place, out of which some were presented earlier in chapter 6.2.3. The model needs to be complemented with further LCA data to account for environmental impacts of more flows, with data about consumption to be able to display actors connected to flows, with data about disposal to display the circularity of flows and finally with mappings of more geographical areas to enable comparisons between more areas. In addition to these developments, there is a need for automating the calculations and validations of results from the model. Building such a software with interactive images requires programming skills. To develop the software in a direction that is relevant for a user, the development should continually receive inputs from potential users.

8. Discussion

The purpose of this chapter is to discuss the meaning of the results, i.e. what they imply in a larger perspective or based on the theory presented in chapter 3. Moreover, the chapter discusses influential factors that have shaped the results or project process. Finally, opportunities for future research are suggested.

8.1 Fulfilment of research aim

One goal of this thesis was to provide suggestions on how to increase the accessibility of the UMAn model which in turn may enable a broader basis for decisions impacting the city's metabolism. To this end, suggestions have been provided for how some aspects of the model can be visualised as part of a software to facilitate more practical use of the data. Visualised software components have entailed queries on different levels of detail to serve the needs of Circular Gothenburg. In relation to this goal, it is important to stress that data from the UMAn model constitutes a *complementary* perspective to the knowledge that the municipality already possess and hence does not provide all answers. Moreover, there is still some way to go before the suggested software components presented in this thesis may enable such support as they first must be developed based on accurate data and put into practice.

In answer to the first research question - *what types of use could Circular Gothenburg have of the UMAn model?* - several components have been suggested that have more or less relevance. Using the model as a basis for prioritisations has proven to be its main value. Looking at the different activities *Plan*, *Investigate*, *Test*, *Implement*, *Follow up* and *Evaluate* that are all important in the work of Circular Gothenburg, the model is least useful for *Test* and *Implement*. This correlates with the view of the UMAn research team. However, as information about the environmental impacts and not merely the mass of flows seems crucial to users, the results suggest that it is in the combination with LCA data that the model becomes most useful. An important aspect to consider is however that the needs that have been mapped in this study derive from a small group of people. They may therefore be subjective and not reflective of the needs of the rest of the municipal organisation. Furthermore, these needs may be subject to change as the project frames of Circular Gothenburg shift slightly depending on what is granted by funding. The second research question - *how can data from the model be made more intuitive and user friendly?* - was explored through different strategies for visualisations. Rather than using the same strategy for all functions, a variety of strategies such as Sankey diagrams and pie charts made it possible to efficiently communicate the information specific for each function. However, this research question has not been addressed in great detail, and several more iterations in cooperation with the users would be required to find truly intuitive solutions. Again, there is no one correct way of visualising this data, and the strategies presented in this thesis are merely suggestions.

A secondary goal was to initiate relations and collaborations between Circular Gothenburg and the developers of the UMAn model. Related to this aim lies one of the big contributions of this thesis. By bringing these two actors together and lay the foundations for a mutual understanding, this thesis has contributed to a first step in overcoming issues connected to transdisciplinary collaborations. Through the interactions in the process, Circular Gothenburg has gained deeper understanding of the structure, potential and limits of the UMAn model while the UMAn research team have gotten more knowledge about the work and needs of Circular Gothenburg. This deepened understanding of the other party has created a better foundation for a common understanding of the problem of how to develop UMAn for more practical application in the municipality. It also enables Circular Gothenburg to query the model, now knowing what it can provide. Suggested visualisations further constitute a visual language that can serve as a common ground for future discussions. Displaying the value of UMAn on different levels of detail and development has most likely created interest for the model, both now and for the future. This in turn may create incentive, mainly for Circular Gothenburg, to be part of the future development of the model. In this sense, the thesis addresses the issue of discontinuous participation.

8.2 Validity of assumptions

In the beginning of the report, an assumption was made that the UMAn model would present similar difficulties as other MFA based models. To large extent, this assumption was proven correct. The validity of the model, which depends on the reliability of the input data, has been brought up as a concern by Circular Gothenburg. As the access to data on an urban level is limited, the model does include estimations and extrapolations. The validity of the UMAn model has however not been questioned in this thesis, and there may be a need for verifying that it provides good enough data to be used as support within the municipality. Another difficulty connected to MFA models concerns the interpretation of results which can be problematic due to undefined goals. In the case of Circular Gothenburg, they have previously not known what data the UMAn model contains and therefore have not been able to set goals for how to use it or query it in the first place. This naturally makes it difficult to know what data should be used and how it should be interpreted to become relevant for Circular Gothenburg. Interpretation of results can also be difficult due to undetermined system boundaries. This is most definitely the case for Circular Gothenburg who focus both on the municipal organisation and the city in large. This means that the data they request also lays on different system levels. In addition to the difficulties of MFA models presented by other authors, another important difficulty that has been evident in this study has been the inherent complexity of the data. This complexity is particularly problematic when data is to be received by a user and may in itself contribute to difficulties in interpreting results and assessing the validity of the model.

Another assumption that has not been explicitly stated in this report but has had large implications on this thesis is the assumption that Circular Gothenburg would be a relevant user to have as case study. However, the fact that they have requested data on a more detailed level than is currently optimal for the UMAn model raises the question whether that assumption was correct. While Circular Gothenburg does include strategic work, the project has a rather practical and hands-on role in making the transition from a linear to a circular economy happen in practice. This leads them to look into rather specific areas and work with both the municipal organisation as well as the city in large. While the UMAn model can be used for more detailed queries, the accuracy of the data decreases as detail increases. If the main value of UMAn will continue to lay in support for strategic planning and prioritisations then perhaps other user groups should be explored. In conclusion, while there is relevance for Circular Gothenburg to apply the UMAn model practically, the model may in its current state of development prove more useful to other user groups.

8.3 Implications of adopting a user centred approach

The user centred approach stemming from design thinking that was adopted in this thesis created a good foundation for bridging researchers and practitioners. It allowed for consideration of the needs of Circular Gothenburg as well as the possibilities and limitations of the UMAn model. Without this approach, the final results would likely have been different since the understanding for the two parties gained through interviews and observations was not sufficient to provide truly relevant concepts. This became apparent specifically during workshop 3 where some functions that were expected to be highly appreciated were in fact discarded as irrelevant. This misalignment between the expected and actual reception of the software components was presumably a result of the difficulties for Circular Gothenburg to assess the relevance of functions before seeing them represented visually. Apart from the implications that this approach had on the final results, it also affected the project process itself. Anchoring concept development in a specific user required a dynamic process where the direction was set by the needs that were discovered throughout. This made the process rather "sensitive" to feedback from the connected actors. In relation to this, both the user and the product are in this case also rather dynamic as the needs of Circular Gothenburg shift over time and the model is under continuous development. So, while this approach has led to results that are truly relevant for the involved actors, it has slowed down the project process due to changing direction in the development phase that were difficult to anticipate beforehand.

Design thinking implies not only a user centred approach but also an emphasis on the value of results. Viewing research models from the perspective of the value they bring, and seeing them as a product for a customer, counts for a practical way of looking at it. However, in this case, where UMAn was to be developed for more practical use, this perspective was found useful. The conclusion from this realisation is that design thinking is not only a valuable tool within design practices but in research as well.

8.4 Influence of the Challenge Lab approach

The emphasis on dialogue and on students taking on the role as change agents, which is prevalent within Challenge Lab, inspired this thesis to create a link between two actors in the city. Taking on this role, and thereby giving both parties an understanding of each other, has hopefully brought them closer and decreased the risk of misunderstandings in potential future collaborations. While design practices emphasise the importance of working closely with involved actors, the Challenge Lab approach further stressed the importance of also bringing the different actors together. By doing so, this thesis has led to a small step forward towards "*...a future where the treatment of our nature is guided by respect, where natural capital is used efficiently with consideration to sufficiency, and where economic activities are carried out with long-term considerations and consciousness"*.

The fact that 20% of the process was dedicated to finding the research questions has of course limited the scope of the thesis. However, the thoroughness of the work in this initial phase made it possible to anchor the research focus in the needs and interests of connected parties and to identify a topic that was relevant based on the author's personal interests.

8.5 Opportunities for future research

This thesis takes an initial step in making the UMAn model more available and intuitive for new actor sets. However, more work is required before it is practically applicable. The limitations in this thesis present some relevant opportunities for future research. For instance, the visualisations presented are based on hypothetical data and does not take into account the requirements that specific data sets may pose on the design. A next step would be to base visualisations on accurate data to see whether the suggested visualisation strategies presented here prove useful. If continuing collaborations with Gothenburg municipality, it is also important to investigate whether the needs of Circular Gothenburg are valid for the rest of the municipal organisation.

Queries on a more detailed level, which were requested by Circular Gothenburg, may very well be requested also by other user groups. If the goal looking forward will continue to be that the UMAn model should be made more available for practical application, there is a need for developing it to provide greater accuracy in detailed queries.

9. Conclusion

In this thesis, Circular Gothenburg has acted as case study to provide valuable insights into how the UMAn model could be developed for more practical use within Gothenburg municipality. Their needs, combined with the possibilities of the model, have been used as foundation for development of concepts. The results of this thesis display how data from the UMAn model can become more available through a software, consisting of several - and for Circular Gothenburg, relevant - components. They also display ways of visualising these components that may serve as a foundation for the future development of the model. The results suggest that the most relevant application of UMAn lies within planning and prioritising, and that greatest value is achieved when the data is combined with LCA.

A user centred approach has been adopted to take into account both needs and possibilities of UMAn simultaneously. This approach has put emphasis on interactive methods and concept development in close collaboration with involved actors. In this sense, it has proven useful in overcoming common difficulties in transdisciplinary work.

This thesis has displayed that there is indeed an interest from potential users to develop UMAn for more practical application. This advocates future work with continued attention to user needs.

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Appendix

APPENDIX 1 - Phase 1 report

Phase 1 report

Louise Eliasson & Magdalena Johnson

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1. Background

Sustainable development was in 1987 defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (World Commission on Environment and Development, 1987). The definition comprises three dimensions, social, ecological and economic sustainable development. A major challenge to the ecological dimension is the pending threat of climate change. In connection to the Industrial revolution, the world transcended into a new era where human activity became the main cause of environmental change. This era, the Anthropocene, in which humans have become dependent on industrialized agriculture and fossil fuels and are consuming more resources than the planet can provide, is now threatening to push the Earth's systems outside the stabile and desirable Holocene (Rockström et al, 2009). To break this trend and place the world on a more sustainable path forward, society needs to undergo transformative changes on a system level (United Nations, 2015). Transformations on this level require challenging of current solutions for societal functions, such as how we secure energy supply or transport ourselves, as well as the socio-technical systems that fulfil and enable these existing solutions. These socio-technical systems, or regimes, are constructed by several elements including technology, culture, user practices, infrastructure, regulations and science (Geels, 2005). In a large scale transformation, all of these elements need to be considered.

Societal transformations that affect many elements also affect multiple stakeholders, why these processes require collaborative efforts in order to take place. Their complex nature further calls for an holistic approach and integrated solutions. For these kinds of multi-stakeholder processes to be efficiently carried out, there is a need for a neutral space where dialogue can take place and where people can meet on equal terms to explore new possibilities together (Hemmati, 2002).

Challenge Lab at Chalmers University of Technology, which was first initiated in 2014, is a lab-based learning arena that acts as one of these neutral spaces where students, researchers and actors from public and private sectors gather around societal sustainability challenges (Holmberg, 2014); (Larsson & Holmberg, 2017). The activities in the Lab are connected to five knowledge clusters active in West Sweden; Life Science, Transport, Chemistry, Maritime and Urban Future. In the Challenge Lab setting, students act as neutral facilitators leading multi-stakeholder dialogues and development processes and are involved in sustainability transitions as part of education. The core methodology within the Lab is backcasting which has its starting point in principles for a sustainable future and provides opportunities to deal with complex sustainability problems in a systematic way (Holmberg & Robèrt, 2000). This year's (2018) main focuses for the Lab are the thematic areas Mobility, Urban Futures and Circular Products and Services.

2. Theory phase 1

2.1 Leadership for sustainability transitions

To enable societal sustainability transitions, leadership has to make space for change. To reach a sustainable future, it should open up for development supporting both economic, ecological and social aspect of sustainability, as well as for self-leadership and integration of actors, perspectives and disciplines (Holmberg, 2017). As described by Anders Wendelheim (1997), for change to take place, there is also a need for trust. He found that in order to make a group engage in new ways of addressing complex tasks, trust must be felt amongst the group members, otherwise, the group will fall back to old habits and new ways of working will not be achieved. Trust seems to work in up or downcycling spirals, as displayed in the figures below. A lack of trust leads to a separation of people in a group which in turn decreases listening and observing and increases the risk of misunderstanding. Misunderstandings cause even greater lack of trust, and this downcycling spiral affects all actions the group engage in (Jewell-Larsen & Sandow, 1999).

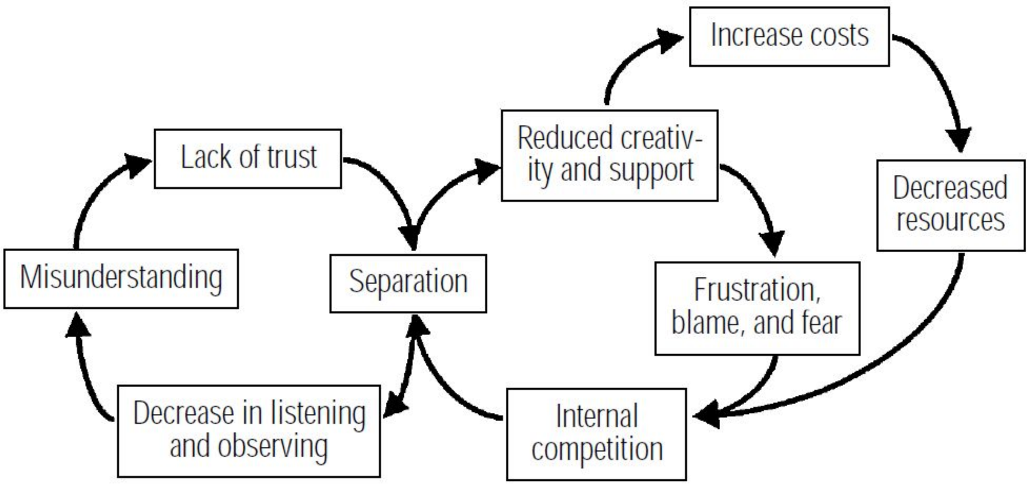

Figure 2.1, the effect of lacking trust (Jewell-Larsson & Sandow, 1999)

Upcycling spirals, where there is trust between members of a group, function in the opposite way. Trust increases collaboration which entails that people listen and observe each other more. This creates an understanding between group members which fosters even greater trust. A group that experiences high levels of trust and collaborates a lot will foster greater creativity, feelings of excitement for their work and increased participation.

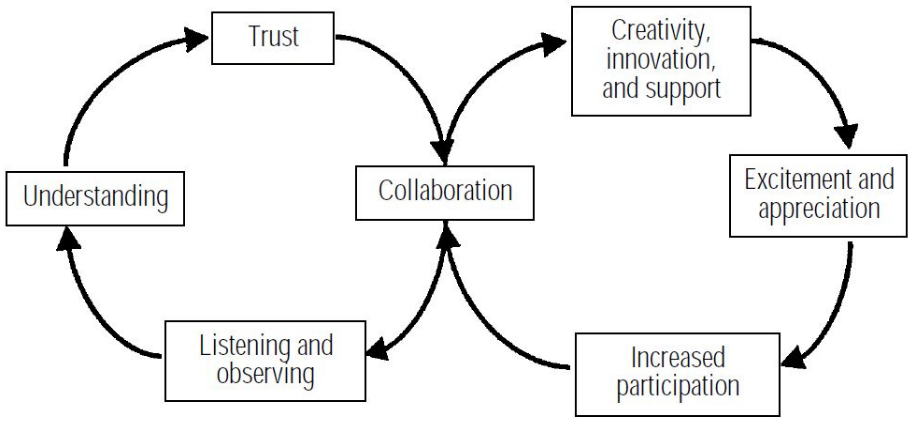

Figure 2.2, the effect of trust (Jewell-Larsson & Sandow, 1999)

2.1.1 System leadership

Systemic thinking considers things, events and ideas in their entirety, meaning that they are treated as wholes with appreciation of their full complexity (Flood, 1998). This way of thinking is needed to find holistic and integrated solutions to sustainability challenges since such challenges cannot be efficiently solved in isolation due to their interrelatedness with the whole of society. The complex challenges the world faces today require the participation and collaboration of multiple companies, business sectors and nations, which calls for leaders who have the ability of systems thinking. Such leaders can typically display possibilities where others see problems and barriers, and are skilled in balancing short-term and long-term value creation (Senge, Hamilton & Kania, 2015). There are three core capabilities that characterizes a system leader; the ability to see the larger system, the ability to foster reflection and generative conversations and the ability to shift focus from reactive problem solving to proactive co-creation. One of the main differences to more traditional leadership is that a system leader strives to create the conditions that can produce change while other leaders try to make change happen by force.

2.1.2 Self-leadership

Self-leadership can broadly be defined as a process of self-influence, and comprises the leading of oneself towards tasks with intrinsic motivation as well as managing oneself to do tasks that may not be motivating (Stewart, Courtright & Manz, 2011). Compared to "traditionally" managed work processes, self-leadership entails influence over what tasks one should do, why those tasks should be done as well as how they should be carried out. This kind of individual self-control has been proven to be one of the most effective means of improving productivity and further leads to enhanced well-being and career success.

In self-leadership, it is important to balance internal and external motivations and so called outside-in and inside-out perspectives. The outside-in perspective means using external knowledge, tools and methods to make sense of an issue while the inside-out perspective focuses on people's inner space, including values, goals, strengths and intrinsic motivations.

Values have been found to have profound impact on people's motivation to engage in large scale challenges as well as their inclination to adopt behaviour that addresses these challenges (WWF, 2010). As explained by Norman Feather (1992, p. 111), "*...values that people hold affect their initiation of new goal-directed activities, the degree of effort that they put into an activity, how long they persist at an activity in the fact of alternative activities, the choices they make between alternative activities, the way they construe situations, and how they feel when an activity is undertaken either successfully or unsuccessfully according to the standards that are se*t". Connecting values and sustainability work, studies have shown that individuals who apply values connected to self-transcendence and openness to change are more likely to be concerned with large scale challenges and more prone to actively adopt behaviours to address them (WWF, 2010).

2.2 Multi-level perspective

Transitions in systems providing societal functions (i.e. energy, water, food etc.), so called system innovations, require consideration of all six elements that together construct a social regime, see Figure 2.3 below. These regimes are actively created and maintained by multiple actors to provide stability to a socio-technical system and the technical solutions for societal functions that exist within them. This strive for stability means that the innovations that take place within the regimes mostly are of incremental nature.

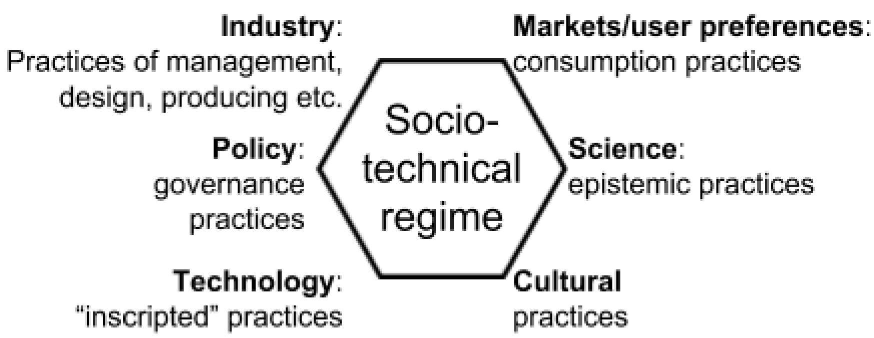

Figure 2.3: The structure of a socio-technical regime (Hasselkuß et al., 2017)

To analyse systems innovations and understand why and how they happen, Geels (2005) introduced the Multi-level Perspective (MLP). The MLP distinguishes three societal levels, the micro-, meso- and macro-level which all affect whether transitions in socio-technical systems take place or not. The micro-level, correlating to the bottom level in Figure 2.4 below, is made up by niche markets and radical innovations. The meso-level is made up by a patchwork of socio-technical regimes, keeping socio-technical systems and markets steady. Finally, the macro-level is made up by the socio-technical landscape, formed by wide external factors such as sustainability challenges and globalisation. While the first two levels may be influenced by the will of an actor, the macro-level lays beyond such influence. The levels are embedded in one another where niches are part of the regimes and the regimes part of the landscape. For a transition to happen, there needs to be an interplay between development at all three different levels. For example, the regimes may be pressured by developments at the landscape level or there could be problems within the regime that cannot be solved using established technology, giving opportunities for niche technology to break through and become part of a new socio-technical system.

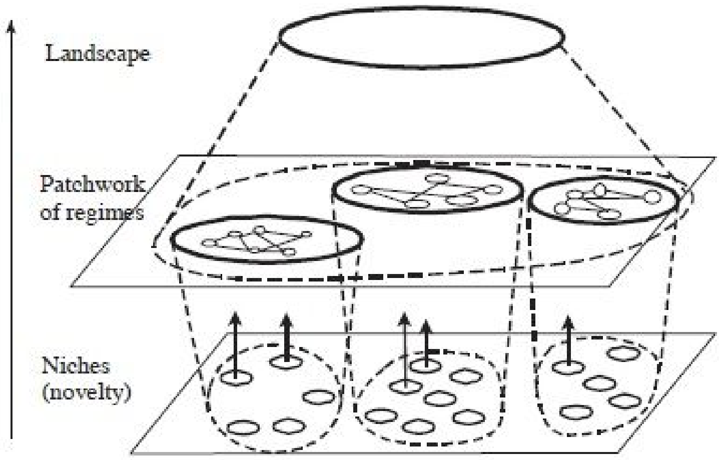

Figure 2.4, the Multi-Level Perspective visualised in its three levels. (Geels, 2005)

2.3 Leverage points for system interventions

Leverage points can be defined as interventions in a system where a small shift can lead to large changes. Donella Meadows (1997) have identified ten categories of leverage points which have different potential in spurring change, ranging from low to high according to;

9. Numbers (subsidies, taxes, standards)
This category is concerned with parameters and minor adjustments in existing systems, without creating any larger change. Even though the category rarely change behaviour, it is a popular leverage point since it is rather easy to apply.
8. Material stocks and flows
How materials are arranged or flow through a system may largely affect how it operates. One main focus in this category is buffer sizes and how they affect the stability of a system.
7. Regulating negative feedback loops
Negative feedback loops aim to self-correct systems, but are quite often discarded as they are perceived to be costly. However, as these loops help keeping track of system goals and can prevent that systems are exploited, they can constitute good leverage points.
6. Driving positive feedback loops
Positive feedback loops reinforce themselves and can drive both the growth and the collapse of systems. The leverage point here then, is concerned with reducing the speed of the positive loops.

5. Information flows
Shifting the route of information or adding information streams can create better conditions for effective feedback and in turn aid in avoiding malfunctioning systems.
4. The rules of the system (incentives, punishment, constraints)
The rules applied in a system determine its framework and further decides how free one can be within those frames. Changing the rules of a system has the potential of leading to radical change.
3. The power of self-organization
According to Meadows, this leverage point is about "*surviv[ing] change by changing*", hence to implement new structures in the system in order to adapt.
2. The goal of the system
The goals of a system form all underlying activities within that system and thereby constitute a great leverage point.
1. The mindset or paradigm out of which the goals, ruler, feedback structure arises.
The shared mindsets and paradigms within a system form everything that happens within the systems as well as how people think about these activities. If intervening in a system on this level, it can be transformed completely.
0. The power to transcend paradigms
Being completely independent of paradigms and recognising that no paradigm is "true" is according to Meadows the highest leverage point there is as this opens up for the opportunity to apply the paradigms that will best help achieving the system goals.
(Meadows, 1997. p.1-2)

2.4 Systems perspectives in sustainability efforts

Environmental issues are to large extent being discussed in isolation, partly because of scientific uncertainty, without taking into account their interrelatedness. This is highly problematic as these issues are becoming both more global and more complex (Holmberg, Robèrt & Eriksson, 1996). Focusing specifically on the transition towards a circular economy, which is one strategy for reaching a more sustainable future, the Ellen MacArthur foundation also acknowledges the importance of thinking in "systems" and claims that being able to understand how different parts influence the whole, and the influence of the whole on the parts is crucial within sustainability transitions (Ellen MacArthur Foundation, 2013).

However, as discussed by Flood (1998), investigating a system using holistic approaches will most likely only lead to the conclusion that everything is interrelated. As such a realization may not be of much use, it is important, for the sake of pragmatism and manageability, to limit the system perspective.

2.5 Backcasting

Backcasting is a planning methodology with a starting-point in a desired future state, that can be used for planning under uncertain circumstances (Holmberg & Robèrt, 2000). By focusing on a desired rather than expected future, it sets the search for future solutions free from present systems. While more traditional methods, such as forecasting or scenario planning focuses respectively on what the most likely future or set of possible futures will be, backcasting focuses on what future that *should* be, as represented in Figure 2.5 below.

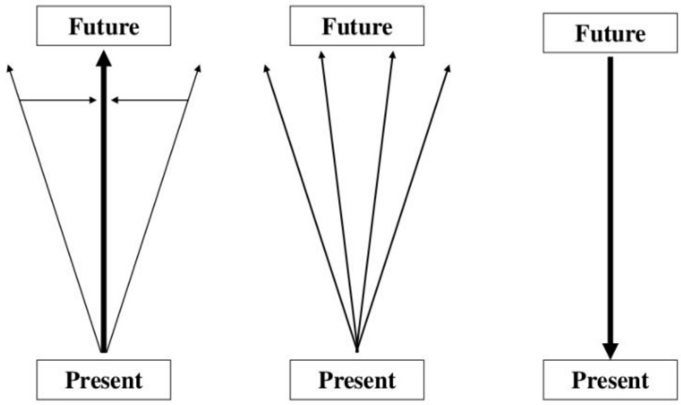

Figure 2.5. From left to right; visualisation of forecasting, scenario planning and backcasting

Backcasting is particularly suitable when the problem to be addressed is complex, calls for large changes, where the current system is part of the problem and when the time horizon makes room for multiple alternative routes (Dreborg, 1996). As described by Vergragt & Quist (2011. p.748). *"one of the salient characteristics of sustainability is that it is a systemic multidimensional concept that encompasses the environment, human well-being, equity, human development and the economy; and that it is mostly conceptualized as a long-term societal goal or objective"*. Hence, challenges linked to sustainability are typically well-suited for the backcasting methodology as they concern multiple and interconnected dimensions of society and need to be addressed over long periods of time.

3. Methods, phase 1

This chapter describes the key activities in *Phase 1* that lead to the research questions of *Phase 2*. Backcasting (Holmberg, 1998) was used as an underlying method during the whole process where *Phase 1* contains Step 1 and 2 of backcasting and *Phase 2* focuses mainly on Step 2 and 3. The backcasting method is first briefly described in its entirety and then Step 1 and 2 are described more thoroughly in accordance with how they were executed within the project. Step 3 is more thoroughly described in methods for *Phase 2*.

3.1 Backcasting

The backcasting method, as described by Holmberg (1998), suggests a four-step process, represented in Figure 3.1 below.

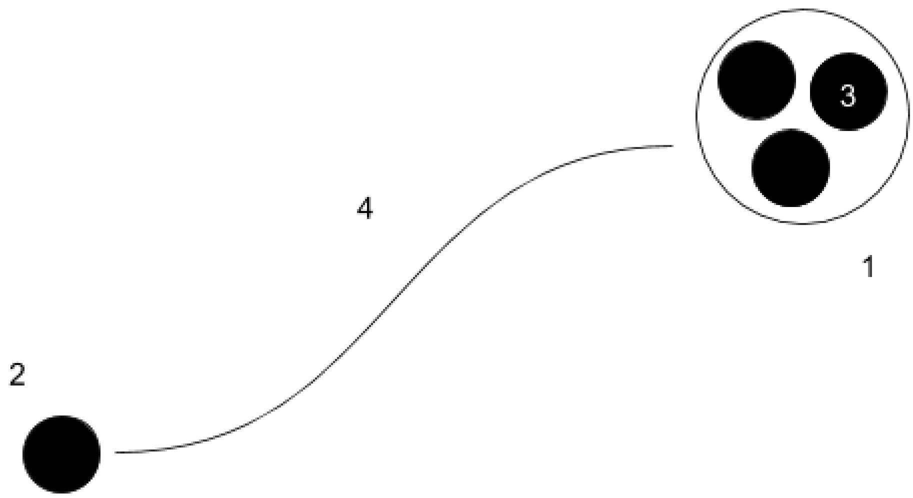

Figure 3.1, overview of the steps of backcasting. Own illustration based on (Holmberg, 1998).

Step 1 *Sustainability framework and principles* - Initially a sustainability framework is put together. This is done by formulating principles that should be general enough to find agreement about but specific enough so they inspire to actions. A principle should not be directed towards one specific action, rather give rise to multiple possible actions. This framework of principles should consist of all relevant sustainability dimensions (ecological, economic, social and well-being) and represent the basis of a desirable world to aim for.

Step 2 *Present state and gap identification* - The present state is investigated and put in relation to the sustainability framework. Here, the present state might be investigated within a certain topic, and all principles from the framework might not be relevant to involve in a specific piece of investigation. The aim is to identify gaps in which efforts need to be made in order to reach sustainability.

Step 3 *Solutions to bridge gaps* - Possible solutions to bridge the gaps are ideated and tested towards relevant stakeholders. Through feedback and evaluation, the ideas are iterated until a suitable concept can be taken further.

Step 4 *Strategies to implement solutions* - Through entrepreneurial thinking, strategies for implementation of the concept are put together. Here the process may look differently depending on the concept characteristics.

3.1.1 Step 1 - Sustainability framework and principles

The starting point for forming a sustainability framework was the pillars of *Wellbeing*, *Social*, *Economy* and *Ecology, shown in Figure 3.2 below.* (Holmberg, 2017). All participants from the Challenge Lab were working together to form this framework. To include everyone's perspectives, a method of circulating groups was applied. For each of the pillar headlines, a secretary was assigned. Groups of three were then circulating around the topics to discuss what was important to include under each headline. After all groups had discussed each headline, the secretaries concluded the material on whiteboards in form of categories and keywords. The role of those categories and keywords was to enrich the headlines and inspire the formation sustainability principles. The material on the whiteboards were discussed in the full group of Challenge Lab participants and final adjustments were made. The material was then concluded in a shared digital document. The created framework is highly subjective and should therefore not be seen as comprehensive but rather a representation of the participants' view on sustainability.

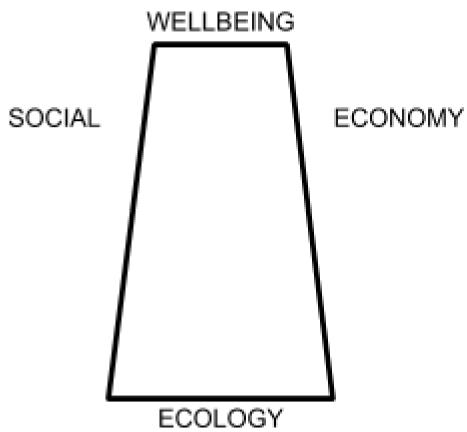

Figure 3.2, the four pillars of sustainability (Holmberg, 2017).

With the sustainability framework as a basis, specific principles were formed in smaller groups. The principles for this thesis were formed in relation to the thematic area of *Circular products and services* and only included keywords relevant to this.

3.1.2 Step 2 - Present state and gap identification

To investigate the present state of the region, literature studies, stakeholder dialogues and workshops were executed. Initial stakeholder dialogues around the thematic areas *Mobility*, *Urban Futures* and *Circular Products and Services* were first held in November 2017 and complemented with further dialogues in January 2018. The initial stakeholder dialogues were executed as part of another course, *Managing Stakeholders for Sustainable Development*, and the Challenge Lab participants took part of the content either by participating in the dialogues or by reading summarised material. The stakeholders that were present during these dialogues were invited by the coordinator of Challenge Lab. Additional dialogues were facilitated by the Challenge Lab participants and stakeholders were invited both by the coordinator and by the participants themselves.

In the initial phase, the Challenge Lab participants also performed literature studies of their thematic areas of interest. For the thematic area of *Circular products and services,* documents about regional strategies, ongoing projects and circular economy were studied. When a knowledge base had started to form, a workshop was held where the Challenge lab participants got to choose a thematic area of interest. Each thematic area was then given a whiteboard with a system structure of landscape, regime and niches, corresponding to the micro-, meso- and macro-levels in the MLP model by Geels (2005). The participants got to add their insights about the present state of the region in a suitable position in the system structure. When the board covered all insights gained, the participants connected aspects that could be clustered together. The content of the board was then presented in the bigger group where feedback and further insights were gathered. This was followed by a iterative process where aspects where rearranged and added to the boards while new insights were gathered by further literature studies and additional stakeholder dialogues.

When the boards were finished, the present state was studied in relation to the sustainability principles formulated in *Step 1*. Gaps between the sustainability framework and the current situation of the region were investigated and described as challenges, where each challenge could be connected to one or more topics which in turn were connected to one or more leverage points (Meadows, 1997). Challenges, topics and leverage points were mapped and iterated through workshops, presentations and feedback within the group. Additional stakeholder dialogues contributed to the iteration and refinement of the material. The direction for this investigation was guided by both an *outside-in* perspective and an *inside-out* perspective (Holmberg, 2014). Identified leverage points were evaluated by assessing how strong they were, using the Meadows (1997) framework as starting point. Selected leverage points were further described by specifying their connected stakeholders, benchmarking examples and connection to ongoing projects in the region. These were then presented in the big group where feedback was given for final refinements. After this, the Challenge Lab participants were divided into thesis partner groups, each focusing on one particular leverage point. For this thesis, two supervisors from different departments were then identified, and from meetings with supervisors, the examiner and stakeholders, the leverage point was altered and refined. The result of these iterations was a refined leverage point with connected research questions.

4. Results, phase 1

This chapter describes sub- and concluding results from *Phase 1*. The concluding results from this phase will be the starting point for *Phase 2*.

4.1 Sub-results

The sub-results from *Step 1* and *2* were collectively created by the Challenge Lab team. All outcomes will not be accounted for, but focus lies on those considered relevant for this thesis. *Step 2* is only describing results from the thematic area of *Circular products and services*.

4.1.1 Step 1 - Sustainability framework and principles

The thematic area of *Circular products and services* is strongly connected to the headlines of *Ecology* and *Economy*. The headlines of *Wellbeing* and *Social relations* are therefore only described briefly in the table below by listing categories and keywords, while *Ecology* and *Economy* are further developed into principles connected to *Circular products and services*.

Table XX, the sustainability keyword framework.

Category	**Keywords**
WELLBEING	
General	Equity, Equal opportunities
Knowledge	Access, Education, Broader connection, Global participation
Autonomy	Deciding one’s own fate, Freedom, Ownership of time, Independence
Self-fulfillment	Space for self-expression, Self-development, Recreation, Opportunity to pursue happiness, Spirituality
Purposefulness	Sense of purpose, Love, Appreciation, Respect, Contribution
Belonging	Community, Culture, Acceptance of diversity, Personal independence, Family, Acceptance, Freedom, Positive social interaction, Identity, Inclusion
Subsistence	Sufficiency, Clean water, Clean air, Food security, Minimum wage, Nutritious food, Home, Safety, Secure, Employment
Health	Green spaces, Weather, Access to healthcare services, Recreation

SOCIAL RELATIONS	
Horizontal relations	Helping each other, Trust, Empathy, Acceptance, Openness, Communication, Cooperative, Learning, Respect, Participation
Vertical relations	Transparency, Awareness, Responsibility, Accountability, Representation, Integrity, Alertness, Adaptability, Trust, Respect
Equity/justice	Legal/normative rights and opportunities, Fairness, Power balance, Impartiality, Consciousness, Inclusion, Access to education/freedom/safety, Welfare, Freedom of movement
ECONOMY	
General	Long-term vision, Conscious consumption, Fair distribution, Transparency
Natural capital	Efficiency, Sufficiency, Substitutability
Man-made capital	Sharing, Dematerialization, Flexible & adaptable systems, Life-cycle assessment, Maintenance
Human capital	Shared & accessible knowledge, Collaboration
Financial capital	Growth indicators, Fair distribution of wealth, Responsible investments
ECOLOGY	
Meeting needs	Planet, Living beings, Today, Tomorrow
Crust alterations	Reversible
Serve environment	Preserve, Protect, Restore, Regenerate
Produced/extracted substances	Degraded, Reabsorbed, Reasonable timeframe

Sustainability principles of *Economy*

I) Economic activities are carried out with long-term considerations and consciousness
II) Natural capital is treated efficiently and used with consideration to sufficiency and substitutability
III) Man-made capital is shared, dematerialized, flexible, adaptable and carefully maintained
IV) Human capital is collaborative, shared, transparent and accessible
V) Financial capital is responsibly invested

Sustainability principles of *Ecology*

I) Today's needs of the planet and living beings are being met, without compromising the ability to meet the needs of tomorrow
II) Alterations made in the crust or biosphere are reversible
III) The environment is served by preservation, protection, restoration and regeneration
IV) Substances are produced and extracted so that they can be degraded or reabsorbed within reasonable time

4.1.2 Step 2 - Present state and gap identification

Looking at the current state of the region within the thematic area *Circular products and services,* there are multiple challenges that needs to be addressed. Some particularly interesting areas are:

- A need for criteria for increased use of bio-based materials in public procurement
- Sharing the findings from pilot projects with industries who could be influenced to make sustainable transitions
- Strategies to reduce the usage of plastic in Gothenburg
- Strategies for increasing industrial symbiosis whilst decreasing use of non-renewable resources and/or fossil feedstocks in industry
- Mapping out relevant actors and possible symbiosis processes for plastic waste in VG region or Sotenäs Municipality
- Working with the city to create a city wide plan for circular economy
- Identify strategy for the city to reach the city (and/or UN) targets for reducing food waste
- Strategies for increasing the possibilities of urban farming in the region

Insights gained during the dialogues, from both researchers and actors in the region, suggest that efforts towards circularity are made on many fronts but are to large extents being developed in isolation. For instance, this is true for efforts made on the topic of systems perspectives within research and within practical work carried out by the City of Gothenburg. In the research sector, a model to trace material and product flows in the city is currently being developed, which has the potential to give system level understanding of urban metabolism. In the City, circular projects have been initiated, but without a clear system perspective, although the City is infact one of the major actors deciding how materials are being used in Gothenburg. This shows that research on material flows is not conducted in collaboration with the City of Gothenburg and that the City may not have the system perspective required to make informed decisions. Scientific models developed by researchers may therefore be unsuitable to apply in the City's practical work in their current state and may need customization to be truly useful.

This gap most clearly relates to the sustainability principles of *Collaboration* (Economy IV) and *Responsible investments* (Economy V), as broader perspectives, gained partly through participatory work, could result in better collaboration, more informed decisions and more responsible investments. A strong leverage point connected to this gap is to enable conditions to apply a system perspective on material flows in the practical efforts in the City. There are specific stakeholders (researchers developing the scientific models and people within the City of Gothenburg) who would benefit from being involved, which provides an opportunity to gain insights on how these actors work with a systems perspective and possibilities to give recommendations on how they could work more collaboratively. The interest for this gap and leverage point is further increased if viewing it from a design perspective. A design process could be a suitable way to approach this challenge, which correspond well with both thesis writers educational background of Industrial Design Engineering. For these reasons, this gap will serve as the base for *Phase 2*.

4.2 Concluded results

With the subresults as a basis, the concluding result from phase 1 are the following two research questions.

> **RQ1**: Is there a need for system perspectives in the practical work within the City of Gothenburg, and what preconditions are required to enable an application of such perspectives?
> **RQ2**: How does current research relate to the City's efforts and how could it be customized and formatted to constitute a tool in their work towards a circular economy?

Four main stakeholders will aid in answering these two research questions. Three of them come from the City of Gothenburg, working with projects connected to circular economy. The fourth stakeholder is a researcher at Chalmers, conducting *Material Flow Analysis* research. The project will have two supervisors where one will contribute with the system perspective on material flows and the other with support in the design process.

5. Discussion

In the formation of the research questions, there were both *outside-in* and *inside-out* influences. The gap that unfolded during the stakeholder dialogues was fused with the *inside-out* influences of personal interest and educational background in a desire to make the most of our previous competence. There was also an interest of writing a thesis that would be concrete yet could contribute with high-level strategic changes. Another wish was that it should have a clarified receiver and chances to contribute practically. When iterating the research questions, these influences were weighed back and forth in an attempt to find a balance where they all could be included. As a result, the research questions address the most interested stakeholders while also making sure ideation and visualization is not excluded from the process. Our hope is that by drawing on the insights of the involved stakeholders, we will be able to create relevant material that can bridge the identified gap.

When considering places to intervene in a system listed by Meadows (1997), the identified leverage point directly relates to redirection of information flows. However, redirecting these specific information flows could in turn lead to larger impacts such as changing the goals of the entire system. A project following these research questions will not likely result in transformative change in itself, but could create conditions for transformative change to happen. By approaching these two research questions, the intervention we will accomplish will mainly operate on the regime level of Geels (2005) MLP. In the socio-technical regime, the project outcome could have an effect on the elements of culture by changing practises around collaboration and system thinking, as well as that of industry by redirecting goals.

As students intervening in today’s regime, we can take on a neutral position where mediation between different actors of the system can have a positive impact on trust and collaborations (Hemmati, 2002). One underlying objective of the project is to test the role of system thinking on material flows in these practical processes, to query where a system perspective provides benefits and where it may act as a barrier. Bridging the gap could lead to improvements in planning and prioritization of efforts in the city, help the City make better informed decisions in projects and make collaboration possibilities within the city more visible. These kinds of improvements may speed up the transition towards a more circular city.

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APPENDIX 2 - Interview script Circular Gothenburg

Background information on project in focus (= *project*)

- Please, describe your role in *project*
- If this project moves according to plan, what will you have achieved when the project is finished?

[Journey Mapping]
Use journey mapping where the interviewee divides *project* into different phases. The interviewee then describes the Activities/decisions, Needs and Challenges in each phase.

Challenges and support in daily work

- How does a typical day look for you?
- What specific challenges do you face in your work?
- What support do you have that can help you in your work? For instance support you to make good decisions.
    - Is any support particularly helpful?
    - Do you miss any support?
- The projects you carry out in Circular Gothenburg entail changes in how we handle resources in the city. How do you investigate where there are possibilities to change and who that can change?

Strategy work

- What is your role in the strategy work of Circular Gothenburg?
- How do you make the strategies within Circular Gothenburg? What shapes them?
- What challenges do you face in your strategic work?
- Do you have any support in this?
    - Is any support particularly helpful?
    - Do you miss any support?
- How do you prioritize what Circular Gothenburg should do?

Holistic perspectives on resource use

In our view, holistic perspectives are about viewing things in their entirety, with consideration to their full complexity and interrelations with their surroundings.

- Does holistic perspectives mean something else for you?
- In your view, what does "a holistic perspective on resource use" mean?
- From what we know about the UMAn model, the holistic perspective on material flows that this could provide may
  ...give an understanding for the impact from different economic sectors

...give an understanding for critical flows
...give an understanding of what products that are part of critical flows
...give an understanding for how your decisions and activities affect the city

- What are you spontaneous reactions to this?
- If you would work actively to apply more holistic perspectives on resource use in your work, how do you see that that would be done?
- Do you see value in incorporating more holistic perspectives in your work?
- Do you see any barriers or negative aspects of doing so?

APPENDIX 3 - Interview script UMAn

General questions

- What is your relation to the UMAn model?
  - How did you get in contact with it?
  - What made you work further with it?
  - What part does it play in your current work?
- What has been the purpose when developing the model?
  - How has this purpose directed the research?
- What kind of change have you hoped to achieve by developing the model?
- Who is the prospective client/user of this model? Who would benefit from the data?
- How does the UMAn model differ from other MFA models?
- What are the model's limitations?
- How reliable is the model?
- How do you and your team work with the city and its industries?
  - How much are they involved? How do you perceive their interest?

Value proposition canvas

Products and services

- In what format is the UMAn model used and "delivered" today?
- What potential products and services do you see around this model? Who would be the provider of this?

Pain relievers

- Do you believe the potential users are struggling with something that the model can offer support in?
- Is it functional pains? Social? Emotional?*Examples could be to produce savings, kill frustrations, lead to better performance, decrease risk, eliminate fear, increase credibility….etc*

Gain creators

- According to you, to whom would the UMAn model be valuable?
- What kind of data or results would be possible to deliver with the UMAn model today?
- What do you think are the most valuable aspects with it?
- Is there any particular result/outcome that would be hard to gain in other ways/using other models?
- Apart from what you can do with the model today, do you see any more potential to what it eventually could deliver?
  - What needs to be done for it to deliver this? Development potential?
- If thinking even further ahead - what are your visions for the model?

APPENDIX 4 - Plan Workshop 1

1. Customer profile

- Present our image of the customer profile
- Co-create a new customer profile where Circular Gothenburg gets to rearrange/add/take away or rephrase aspects
- Let Circular Gothenburg prioritize amongst the aspects in the customer profile to show which are more important/urgent.

2. Value map

- Prenets the value proposition of the UMAn model
- Co-create a desired value proposition by letting Circular Gothenburg add desired aspects and prioritize amongst the already existing aspects. Try to understand which are more relevant.

To keep in mind during the conversations in point 1 and 2

- *What data are they looking for?*
- *In what way do they wish to see the data?*

3. Scenarios

- Present two future scenarios that allows Circular Gothenburg to think outside their current limitations concerning time, financing etc.
    - Scenario 1: You have access to a portal where you can search for information. The data is easily available. Other actors also have access to the same portal. The portal allows you to simulate and evaluate different efforts. How would this portal look? What information are you searching for in it? How/in what situations would you have used it?
    - Scenario 2: The data from the UMAn model is used for gamification. All citizens in Gothenburg have access to this game where they can build and see the effects of different scenarios for the material flows in the city. How would this game look? What information would it include? How/in what situations would you have used it?

4. Future for Circular Gothenburg

- Let's imagine that we are 10 years ahead in time. Circular Gothenburg is part of the city's original budget and you have a team of 15 people working on it. How, and with what do you work?

APPENDIX 5 - Plan Workshop 2

1. Presenting (in general terms) case study background and needs.

Circular Gothenburg is a three year financed project where the aim is to use resources more efficiently, primarily within the municipal organisation but also to make it easier for citizens to be more resource efficient.

Jobs

They do many projects at the same time and their focus in terms of materials or waste flows is mostly on bulky waste. Other flows of interest is plastics and food but there are other people and departments in the municipality working more with those areas. Their focus is mainly in their own organisation, and so, they seek information specific for that. They reason that even though a flow would be critical, it wouldn't be too interesting to address if they cannot influence it as an organisation, or if the intervention would be huge and demand a lot of resources. Then they would rather focus on low-hanging fruits. They see themselves as do:ers that make things happen in practise, therefore planning and strategizing is only somewhat incorporated in their practical work. There is a tendency to go where interest lies. They meet a lot of actors, that either contact them or they contact because they have identified them as important for a certain project. They gather information from these actors, and coordinate collaborative networks. With these insights from multiple actors they can also inspire and facilitate change. Circular Gothenburg as a project is limited and steered by its funding, regulatory documents and decision boards, but they also have the possibility to effect these preconditions by providing information.

Pains

They perceive that their overall goals are quite clear, but that they are lacking clear milestones for reaching those goals. In some cases, they find it hard to know how much of something they need to do for it to make an environmental difference. They sometimes find it hard to limit a project scope or to prioritize among multiple activities. There is also the issue of role division, if they really are the right actor to execute certain activities or if it is actually some other actor in Gothenburg that should have the responsibility, due their possibility to influence that certain activity.

Gains

They see a value in having further information support when making decisions, but they are not interested in analyzing data themselves, this data would need to be already analyzed, clear and ready to act upon. It also need to be trustworthy and transparent for it to be perceived as valuable. Another gain would be to actually reach the overall goals, and be able to view the progress along the way.

2. Presenting and discussing different functions

Ask them to place these functions on a timeline.

- What can be done, when? (In relation to each other)
  - 1 now?
  - 2 with alterations?
  - 3 future possibilities?
- How long is the timeline in your view? Approximately. Any milestones?
- What could we create already now within the thesis?
- Any function missing that you think would be valuable for the municipality?

Go through each function and investigate:

- Data/input required: What input is then needed to realize this function? What data would be used? If adapted - how? Combined with what?
- Model development: What development needs to happen?
- New ways of working for the municipality?: What would be required from the municipality?

APPENDIX 6 - Plan Workshop 3

1. Give everyone a chance to get to know each other

- Presentation round

2. Go through visualized concepts and receive feedback

Show what we've developed by matching the customer profile and value map. Show the concepts on the timeline. Go into all separate concepts for deeper discussion.

1. Overview of flows

- Go through the gates in the Sankey diagrams. Are they relevant? Would other gates have been more relevant?
- Describe the flow. Is it intuitive and possible to follow?
- Describe how one should interact with the image. Is this a good way of doing it? Would any further interactions be relevant?

2. Hotspots and environmental impacts

- Show how this could be used. Is it a desired function? How do they want to receive the information (numbers, images, text)? Do they want to do something else with the data?

3. Effect goals/simulations

- Describe the idea: "If you wish to achieve a decrease in emissions with …%, how much do we then have to decrease flow A, B & C?". What are their thoughts on the function? Would they use it? Do they see value in adding anything else to this functio? Would they want to interact with it differently? Do they have scenarios that they would want to run?

4. Interrelations with other regions or countries

- What are their thoughts on the function? Would they use it?

5. Zoomings: Actors connected to flows (in terms of economic sectors) + Overview of their own consumption

- Describe how the interactions work. What are their thoughts on the function? Would they use it? Do they see value in adding anything else to this functio? Would they want to interact with it differently?